Collecting lessons learned

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HOW PROJECT-BASED ORGANIZATIONS IN THE OIL AND GAS INDUSTRY LEARN FROM THEIR PROJECTS

Proefschrift

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door

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Summary

Project-based organizations collect lessons learned in order to improve the performance of projects. They aim to repeat successes by using positive lessons learned, and to avoid repeating negative experiences by using negative lessons learned. Cooke-Davies (2002) claimed that the ability to learn from past projects for future projects is a key success factor in project management. Despite their importance, organizations can be ineffective in collecting and using lessons learned.

To address this issue, this thesis has focused on lessons learned collection processes (LLCPes) as the first part of this problem. The insights presented in this thesis might, in turn, inform how organizations collect and use lessons learned.

This research employs case research and literature studies in order to investigate why LLCPes can be so challenging, and what a LLCP needs to deliver for lessons learned to be usable. The main part of the thesis focuses on LLCPes themselves: on their design, how they are used in order help participants develop lessons learned, and on characteristics of the resulting lessons learned. The case research focuses on (but is not limited to) the oil and gas industry in North-Western Europe. It includes only organizations which were successful in collecting lessons learned.

Usage. This thesis identified four criteria influencing whether lessons learned are fit for use in the future: understandability, appropriate level of detail, quality/maturity of problem descriptions, and the maturity/practicability of described solutions. One of the LLCPes (TerminationCol) indicated, however, that there might be a potential interaction between these criteria, and whether there is an overlap between participants in the LLCP and the usage process.

Apart from these general characteristics, this thesis indicates that the phase of organizational decision making (based on Simon's (1977) framework) in which a lesson learned is used has an influence on what a lesson learned should (ideally) contain in terms of problem descriptions and potential solutions.

The temporal alignment between situations or events described in a lesson learned and the usage context inform the design space ideally considered in the recommendations or actions. Here, several usage situations have been identified. For usage of lessons learned in a project, it matters whether lessons learned are applied reactively (and without preparation) or in order to prevent a problem from reoccurring. Even though lessons learned aim to improve future projects, they are not necessarily used in future projects. Instead, they might be used on an organizational level (such as changing training and guidelines for employees, or refactoring simulation libraries for better performance in future projects) as well.

Last, source credibility and usage expectations (formed during or in the environment of a LLCP) also influence if lessons learned are fit for use.

Challenges. The reasons why LLCPes are difficult to perform in organizations are manifold. This thesis has identified 20 challenges concerning the environment of a LLCP, constraints pertaining to the resources, instruments, and time available for LLCPes, or the participants themselves. These challenges vary in their immediate consequences (or symptoms): they can prevent LLCPes from taking place, limit the resources available for LLCPes, and influence the time certain participants spend on a LLCP (including the possibility of spending no time at all). Challenges associated with the participant influence if and what kind of experiences participants share, and affect how the participants process, analyze, or deal with the experiences underlying a lesson learned.

The study of the LLCP cases suggests that dealing with inter-group and inter-organizational conflicts might be a broader challenge than previously considered. Also, it questions the extent to which it is necessary to elicit tacit knowledge during a LLCP. Last, it suggests that a live capture of lessons learned might have negative consequences not considered in that approach.

LLCPes. This thesis presents 8 actual LLCPes based on 6 abstracted designs, with 5 of these designs focusing on collaborative, facilitated lessons learned collection. Overall, this study of LLCPes shows that facilitated LLCPes vary in their design – they are not a single instrument, but a class of instruments, each instrument with its own characteristics and effects. It provides tentative indications that these LLCPes are transferable to similar collection opportunities, and that they can be adapted during the process. It also shows how participant behavior is influenced throughout the LLCPes, and that, as a consequence, some characteristics of the resulting lessons learned are shaped through the LLCPes. More precisely, the LLCPes shape the topics and the structure of the resulting lessons learned, as well as their quantity and level of detail. Also, they might influence usage expectations, and source credibility. It should be noted that the LLCPes had systematic gaps in their coverage: they only rarely collected positive lessons learned, or lessons learned on products created in a project or department.

A closer look at the LLCPes shows that they influence the outcomes through direct guidance and more indirect influences. The structure of the LLCP and the structure of a lesson learned are two key instruments that provide direct guidance to the participants. Indirect influences are exerted by participant selection and theme selection, for example. Furthermore, the decomposition of LLCPes identifies tentative measures to address the challenges, including the setting in which participants interact (in particular, whether the interactions are anonymous, and whether the LLCP requires participants to collaborate in the same location), the distribution of themes across several LLCPes, and facilitator selection.

Overall, these findings suggest two possible explanations why lessons learned programs might fail: a failure to adequately handle the challenges associated with a LLCP, and a mismatch between the outcomes of a LLCP and the lessons learned needed in a usage process.

Samenvatting

Project-gebaseerde organisaties verzamelen *lessons learned* om de prestaties van hun projecten te verbeteren. Ze streven ernaar om successen te herhalen met behulp van positieve lessen die zijn geleerd, en om negatieve ervaringen te voorkomen met behulp van negatieve lessen. Cooke-Davies (2002) stelde dat het vermogen om te leren van eerdere projecten een belangrijke succesfactor is voor toekomstige projecten. Ondanks het belang van *lessons learned*, zijn organisaties niet effectief in het verzamelen en gebruiken ervan.

Om dit probleem aan te pakken, heeft dit proefschrift zich gericht op het proces van de verzameling van *lessons learned (Lessons learned Collection Processes* – LLCPs) als de eerste stap binnen dit probleem. De lessen uit dit proefschrift kunnen, op hun beurt, organisaties helpen bij het verzamelen en gebruiken van *lessons learned*.

Dit onderzoek maakt gebruik van caseonderzoek en literatuurstudies om na te gaan waarom LLCPs zo uitdagend zijn, en wat een LLCP moet opleveren om de *lessons learned* bruikbaar te maken. Het grootste deel van het proefschrift richt zich op de LLCPs zelf, en behandelt hun ontwerp, hoe ze worden gebruikt om deelnemers te helpen *lessons learned* te ontwikkelen, en wat de kenmerken zijn van de resulterende *lessons learned*. Het caseonderzoek richt zich op (maar is niet beperkt tot) de olie- en gasindustrie in Noord-West Europa. Het bevat alleen organisaties die succesvol waren bij het verzamelen van de *lessons learned*.

Gebruik. Dit proefschrift heeft vier criteria geïdentificeerd die beïnvloeden of de *lessons learned* geschikt zijn voor gebruik in de toekomst: begrijpelijkheid, juiste detailniveau, kwaliteit en volledigheid van de probleembeschrijvingen, en de kwaliteit en volledigheid van de beschreven oplossingen. Eén van de LLCPs (TerminationCol) gaf echter aan dat er mogelijkerwijs interactie is tussen deze criteria, en wees op de overlap van de deelnemers in de LLCP en het gebruiksproces.

Naast deze algemene kenmerken, geeft dit proefschrift aan dat de fase van organisatorische besluitvorming (op basis van het raamwerk van Simon (1977)) waarin een lesson learned wordt gebruikt invloed heeft op wat een lesson learned (idealiter) moet bevatten in termen van probleembeschrijvingen en mogelijke oplossingen.

De temporele afstemming tussen situaties of gebeurtenissen die in een lesson learned worden beschreven en de gebruikscontext, vormt de basis voor de ontwerpruimte die beschouwd wordt voor het ontwikkelen van de aanbevelingen of acties. Verschillende gebruikssituaties zijn geïdentificeerd. Voor het gebruik van *lessons learned* in een project is het van belang of de *lessons learned* reactief worden toegepast (en zonder voorbereiding), of om te voorkomen dat een probleem nogmaals optreedt. Ondanks het feit dat *lessons learned* gericht zijn op het verbeteren van toekomstige projecten, worden ze niet per se gebruikt in toekomstige projecten. In plaats daarvan kunnen ze worden

gebruikt op organisatorisch niveau (zoals het veranderen van opleidingen, het aanpassen van richtlijnen voor werknemers, of het tunen van simulatiebibliotheken voor betere prestaties in toekomstige projecten).

Tenslotte zijn geloofwaardigheid van de bron van de lesson learned en verwachtingen over gebruik (die gevormd worden tijdens de LLCP zelf of in processen er omheen) ook van invloed op de geschiktheid van *lessons learned* voor gebruik.

Uitdagingen. De redenen waarom LLCPs moeilijk zijn uit te voeren in organisaties zijn legio. Dit proefschrift heeft 20 uitdagingen geïdentificeerd met betrekking tot de omgeving van een LLCP, beperkingen in gebruik van middelen, instrumenten, de beschikbare tijd voor LLCPs, en de beschikbare tijd van de deelnemers. Deze uitdagingen kunnen zeer verschillende gevolgen hebben: ze kunnen voorkomen dat een LLCP plaatsvindt, beperkingen opleggen aan de middelen die beschikbaar zijn voor LLCPs, en de tijd beïnvloeden die deelnemers te besteden hebben binnen een LLCP (inclusief geen beschikbaarheid). Uitdagingen die met de deelnemer te maken hebben beïnvloeden of deelnemers ervaringen delen, wat voor soort ervaringen ze delen, en hoe de deelnemers de ervaringen die ten grondslag liggen aan een lesson learned verwerken en analyseren.

Bestudering van de LLCP-cases suggereert dat het omgaan met conflicten tussen groepen en organisaties een grotere uitdaging zou kunnen zijn dan eerder werd gedacht. Ook plaatst het vraagtekens hoe noodzakelijk het is om impliciete kennis te vergaren tijdens een LLCP. tenslotte geven de cases aan dat het direct (live) verzamelen van *lessons learned* negatief gevolgen zou kunnen hebben die niet beschouwd worden in die aanpak.

LLCPs. Dit proefschrift presenteert acht daadwerkelijke LLCPs gebaseerd op zes geabstraheerde ontwerpen, waarbij vijf van deze ontwerpen zich richten op gezamenlijke, gefaciliteerde verzameling van *lessons learned*. Met andere woorden, een LLCP is niet een enkelvoudig instrument, maar een klasse van instrumenten, waarbij elk hulpmiddel eigen kenmerken en effecten heeft. Het onderzoek geeft voorzichtige aanwijzingen dat deze LLCPs overdraagbaar zijn naar soortgelijke omgevingen waar lessen verzameld worden, en dat ze kunnen worden aangepast tijdens het proces. Het toont ook aan hoe het gedrag van deelnemers beïnvloed wordt tijdens de LLCPs, en dat daardoor sommige kenmerken van de verkregen *lessons learned* sterk beïnvloed worden door de LLCPs. Meer specifiek beïnvloeden de LLCPs de onderwerpen en de structuur van de resulterende *lessons learned*, evenals hun hoeveelheid en detailniveau. Ook kunnen ze de verwachtingen over het gebruik en de geloofwaardigheid van de bron beïnvloeden. Wel moet opgemerkt worden dat de LLCPs systematische gaten in de dekking had: slechts zelden zijn positieve *lessons learned* verzameld, of *lessons learned* die gaan over producten die gemaakt zijn in een project of afdeling.

Een nadere studie van de LLCPs laat zien dat zij de resultaten beïnvloeden op zowel directe als meer indirecte wijze. De structuur van de LLCP en structuur van een lesson learned zijn twee belangrijke factoren die directe sturing geven voor de deelnemers. Indirecte invloeden zijn bijvoorbeeld de selectie van deelnemers aan de sessies en de selectie van de thema's. De structuur van de LLCPs bevat een aantal maatregelen om de geïdentificeerde uitdagingen aan te pakken, met inbegrip van de omgeving waarin de deelnemers samenwerken (In het bijzonder of de interacties anoniem zijn of niet, en of de LLCP vereist dat deelnemers moeten samenwerken op dezelfde locatie), de verdeling van de thema's over verschillende LLCPs en selectie van de facilitator.

De bevindingen in dit proefschrift geven twee mogelijke verklaringen waarom *lessons learned* programma's kunnen mislukken: een gebrek aan adequaat omgaan met de uitdagingen in verband met een LLCP en een mismatch tussen de uitkomsten van een LLCP en de *lessons learned* die nodig zijn in het gebruiksproces.

Contents

List of Abbreviations

CII . . . . Construction Industry Institute

FEED . . . . front end engineering and development

GSS . . . . group support system

h . . . . hour or hours

ICT or IT . . . . . information and communication technology

ID . . . . identification

KM . . . . knowledge management

KMS . . . . knoweldge management system

LL . . . . Lesson(s) learned (only used in boxes, figures, and tables)

LLCP . . . . lessons learned collection process

MSc . . . . Master of Science

nd . . . . no data available

PME . . . . post-mortem evaluation

PMI . . . . Project Management Institute

RQn . . . . Research Question n

US or USA . . . . United States (of America)

Abbreviations for Cases and Activities

The following abbreviations were used in the third part to identify cases.

DC .... DepartmentCol

DP .... DeepwaterCol

IC .... InnovCol

RC .... RepositoryCol

RP .... RefineryCol

TC .... TerminationCol

Activity codes are a sequence consisting of three components: <case code><activity type><index>. The following activity types were used:

A .... Authoring activity (only in RC)

D .... Activity in the main phase ("during") of a collaborative LLCP

I .... Activity for obtaining information (only in RC)

O .... Activity in the opening phase of a collaborative LLCP

S .... Supporting activity

Part I

Introduction

Chapter 1

Introduction

Within project based organizations (i.e., organizations structured around projects) there is some concern over retaining the knowledge and experiences gained in a project. Projects are *temporary* organizations (Bakker, 2010). Due to its temporal nature there is a risk that knowledge and experiences obtained during a project will disperse at its end (Williams, 2008). Failure to learn from past projects can lead to repeating mistakes (Ajmal et al., 2010) or to reinventing the wheel. In extreme cases, project based organizations do not learn from their mistakes for years (Ajmal et al., 2010). The ability to learn from projects, and to transfer these learnings from one project to the next, has been identified as a critical success factor for these organizations (Cooke-Davies, 2002). Today, project based organizations also face demands from clients to demonstrate this capability, e.g., through employing improvement techniques (Carrillo et al., 2013; Wiewiora and Murphy, 2015).

Project based organizations can address this challenge by transferring some of the knowledgeable people, such as engineers or project managers, from one project to the next. These knowledgeable people could carry some of their learning with them to next project. However, the number of projects that can be reached this way is rather limited. In addition, knowledgeable people „use their minds. [Thus,] they own their means of production, when they leave, they take this means of production with them" (Stauffer, 1999), depleting the organization of valuable knowledge.

As a result, project based organizations aspire to document knowledge and experiences gained in a project. In this context, lessons learned are a strategy to transfer knowledge between projects (e.g., Gibson et al. (2007); Koners (2005); Newell et al. (2006); Tan et al. (2006); Wiewiora and Murphy (2015)) suggested by current project management standards (Bentley, 2010; Project Management Institute (PMI), 2004). Lessons learned can lead to organizations changing their strategy (reported for 57% of organizations surveyed by Williams (2008)) or their procedures (reported for about 65% of these organizations).

Even though lessons learned processes have been discussed in academic literature for almost 20 years (Collier et al. (1996) provide an early example for a process supporting the collection of lessons learned), case studies, interviews, and surveys show that organizations still struggle with it (e.g., Carrillo et al. (2013); Wiewiora and Murphy (2015); Williams (2008)). In particular, there is a discrepancy between the goals and the outcomes of lessons learned processes (Carrillo et al., 2013). Williams (2008) found through a survey of experienced project managers that, for about 65% of respondents, their organizations collected lessons learned for some projects, but only a much smaller percentage of these organizations actually transferred them to other projects (less than 40% of respondents), or elsewhere in the organization (less than 25% of respondents).

This transfer includes several lessons learned processes, among others a lessons learned collection process (LLCP), in which participants aim to elicit and (optionally) document lessons (based on Weber et al. (2001)), a verification process, in which a team of experts aims to validate lessons learned using criteria set by the organization (e.g., correctness, redundancy, consistency, and relevance) (based on Project Management Institute (PMI) (2004); Weber et al. (2001)), a dissemination process, in which users aim to retrieve relevant lessons learned, or in which lessons learned are distributed to their audience (based on Weber et al. (2001)), and a usage process, in which users aim to apply lessons learned to project-related activities or to use for changing things on an organizational level (e.g., organizational procedures (Gibson et al., 2007; Williams, 2008)), with the intention to achieve the goals of a lessons learned initiative (i.e., projects do not repeat mistakes, and do not reinvent the wheel).

Explanations for the discrepancy between goals and outcomes of lessons learned processes are manifold and pertain to the whole process of transferring lessons learned between projects. For all processes, Williams (2008) identified lack of employee time and lack of management support (and therefore resources) as barriers. Another major reason is a lack of guidance for these processes (Wiewiora and Murphy, 2015). In the same way, (Williams, 2008) observed that, even though project management standards suggest collecting lessons learned, they do not explain how to do it. Lessons learned are difficult to use if they cannot be found, e.g., because they are not stored in centrally (Wiewiora and Murphy, 2015), because they are poorly structured (Wiewiora and Murphy, 2015) or because they do not address underlying causes for project outcomes (Williams, 2008).

Particularly these last issues indicate that, even though organizations collect lessons learned, the results may not be fit for use. In this context, the methods used to collect lessons learned may be partially to blame. Koners (2005) found in her observational studies of collaborative efforts to collect lessons learned, that, while the methods used to collect lessons learned were important, four (out of five) studied organizations did not structure the discussions resulting in lessons learned, leading to ineffective LLCPes.

In order to formulate tentative research questions in Section 1.3 on page 12, this introduction further conceptualizes lessons learned (Section 1.1), and introduce a model outlining the structure of a LLCP (Section 1.2 on page 7). Furthermore, it provides a brief overview of the research design and philosophy (Section 1.4 on page 13).

1.1 What are Lessons Learned?

The term lesson learned is often used as a catch-call phrase in literature. Even in articles defining the term, there is a disagreement on what the term refers to. In order to address this problem and define the term for the scope of this thesis, existing definitions were analyzed with regard to the categories and attributes associated with lessons learned. These categories and attributes were then used to construct a tentative definition of lessons learned.

An overview of some existing definitions can be found in Appendix A. All of these definitions directly or indirectly categorize lessons learned. First, several authors conceptualize lessons learned as an object in a process (Kasi et al., 2008; Von Zedtwitz, 2002). For example, Kasi et al. (2008) considers *lessons learned as an entity in a process*:

„Post mortem evaluation (PME) has long been advocated as a means of improving development practices by learning from IT (information technology) project failures. In theory, PMEs can help individuals and organizations learn what worked and what can be improved upon so that lessons learned in one project can be applied to future projects."

This conceptualization focuses on the purpose of lessons learned and on their role in a process, but does not further define what a lessons learned is.

Others conceptualize lessons learned from a cognitive or behavioral perspective. From a behavioral perspective, lessons learned are the actual *behavior* demonstrated in a project such as good or adverse work practices (Harrison, as cited by Gibson et al. (2007)). From a cognitive perspective, lessons learned can be considered as

- *experiences* gained in a project (Liebowitz, 2008; Schindler and Eppler, 2003) or military exercises (United States (of America) (US) Army, as cited by Weber et al. (2001))
- *knowledge* based on such experiences (Gibson et al., 2007; Liebowitz, 2008) (Bickford, US Army and Space Agencies, as cited by Weber et al. (2001))
- or *learning* gained on a projects (Keegan and Turner, 2001)

Alternatively, some authors introduce a behavioral component: they distinguish between lessons and lessons learned, and stress that lessons need to be applied in the organization in order to be learned.

Last, a lessons learned can be conceptualized as a text[1] or (multi-media) document (e.g., Disterer (2002)). In this context, most authors consider lessons learned as documents or recordings of the aforementioned cognitive concepts (e.g., documented learnings or knowledge (Newell et al., 2006), or recorded experiences (US Airforce, as cited by Weber et al. (2001))). This consideration mirrors a discussion in knowledge management (KM) research on whether knowledge is tied to individuals, or whether it can also be explicated and found in documents. In contrast to lessons learned as documented knowledge, experience or learning, Stewart (as cited by Weber et al. (2001)) defines lessons learned through their form (i.e., lessons learned are guidelines, tips, or checklists). Conceptualizing lessons learned as a document overlaps with lessons learned as an entity in a process, because documents provide the means of transfer between projects.

Overall, lessons learned can be considered as experiences, knowledge, learning, behavior, text (particularly a document), or an entity in a process. These conceptualizations are still very broad, and include entities that may not be lessons learned. Therefore, literature narrows down the definition of a lesson learned through their attributes.

Two of these attributes focus on the origins of a lesson learned. First, lessons learned or their underlying cognitive or behavioral elements have been developed in a

[1] A text can be transferred orally and in writing (it is a combination of sentences forming a whole Linke et al. (1991, p. 215)). This thesis is interested in written lessons learned as an outcome of LLCPes.

specific context. For project-based organizations this context is given through a *project*. Second, lessons learned can be based on *positive or negative* behavior or experiences. This attribute is emphasized through contrasts such as good or adverse work practices (Harrison, as cited by Gibson et al. (2007)), positive and negative experiences as a basis for lessons learned (Space Agencies, as cited by Weber et al. (2001)), „knowledge acquired in an innovation or adverse experience" (Bickford, as cited by Weber et al. (2001)), or processes that aided or hindered performance (Project Management Institute (PMI), 2004). This dichotomy of positive versus negative lessons learned excludes ambiguous experiences as a basis for lessons learned. In contrast, Gibson et al. (2007) includes ambiguous experiences by defining lessons learned as „knowledge gained from experience, successful or otherwise [. . .]".

Another attribute focuses on the *value or purpose* of a lesson learned. On the most general level lessons learned should help to repeat success or avoid failure (Harrison, as cited by Gibson et al. (2007)). Other authors state that lessons learned should be applicable in future projects (Kasi et al., 2008), and provide some benefit (Von Zedtwitz, 2002) or business value (Schindler and Eppler, 2003) in those future projects. Some authors are more precise, stating that lessons learned should improve performance (Gibson et al., 2007), or increase safety, efficiency, or quality (Bickford, as cited by Weber et al. (2001)) in a project. This attribute shows that lessons learned are tied to organizational values and goals.

Last, several definitions explicitly state that lessons learned should be *valid* (Liebowitz, 2008; Schindler and Eppler, 2003) (see also US Army, as cited by Gibson et al. (2007)) or factually and technically correct (Space Agencies, as cited by Weber et al. (2001)). Considering lessons learned as valid is also reflected in the notion of lessons learned as (documented) knowledge. However, not all definitions consider validity of lessons learned a defining factor.

Overall, the analysis of the definitions revealed that

- lessons learned are documents, cognitive entities, or behavior
- the cognitive basis of a lesson learned may be knowledge, experience, or learning
- lessons learned may be positive or negative. Whether lessons learned can be ambiguous is an open research question.
- lessons learned are tied to organizational values and goals
- some authors assume that lessons learned have to be valid

Based on these categories and attributes, this thesis uses the following definition of a lesson learned:

A lesson learned is a text or (multi-media) document that is based on experiences made in a project and that has the potential to provide value for future projects.

Positive lessons learned are lessons that are based on positive experiences in a project, and negative lessons learned are lessons that are based on negative experiences in a project. The definition has several advantages. First, it reflects the purpose of a lesson learned in the context of this thesis in that lessons learned are collected with the intention to help future projects to prevent mistakes or avoid reinventing the wheel. This purpose captures the notion that lessons learned are tied to organizational values, because these organizational values help define what constitutes a mistake or a success. At the same time, the definition makes no assumptions about the values itself, or about the actual effects when using the lessons learned.

In contrast to considerations of lessons learned as behavior, this definition allows a documentation of emotions, personal perceptions, or any reasoning underlying past decisions.

Furthermore, this definition does not assume that lessons learned are cognitive entities tied to an individual. Instead, categorizing lessons learned as a document based on experiences allows a lesson learned to be constructed during a collaborative effort, without any single individual having the full learning or experience underlying a lesson learned.

Defining lessons learned as a text or document based on experiences instead of documented knowledge avoids assumptions on whether lessons learned are valid (or have some form of justification). Rather, validity is considered an attribute that a lesson learned may or may not have.

Last, while the focus on texts or documents assumes that knowledge (if present) is explicated, it does not make assumptions about a mixture of forms. It allows for transferring lessons learned orally or in writing, and includes multi-media documents.

1.2 Basic Model of LLCPes

It is not easy to collect lessons learned that can help to prevent mistakes or to repeat successes in other projects, and it is not clear to what extent current LLCPes actually achieve their purpose (Williams, 2008). To address this issue, this thesis aims to explore the structures and dynamics of LLCPes. In order to further our understanding of LLCPes, and in order to be able to formulate research questions, this section presents a basic model of LLCPes.

The model is derived from literature studying factors that influence individual and group behavior, as well as the interaction of individuals with a knowledge management system (KMS). It is a synthesis of objects and entities relevant for group performance (suggested by Nijstad (2009)) and a model explaining the success of KM initiatives (Kulkarni et al., 2007), and has been extended and adapted to LLCPes.

Overall, it consists of six components (see Figure 1.1 on the following page; the LLCP itself is denoted through the dotted rectangle):

- the participant(s): one or more individuals contributing to the lessons learned
- the output or product of the process: mainly the collected lessons learned
- the environment of a collection process: it is everything outside of a single effort to collect lessons learned, and encapsulates the other components
- instruments (e.g., hardware or software tools, procedures, facilitation techniques) and supporting roles that are intentionally used to influence individual and group behavior during the collection process

- some additional properties of the LLCP such as the task goal of the collection process, and its duration

Overall, the model assumes that various factors (such as the task goal, or the instrument) influence the participants during a LLCP, who, in turn, gradually produce the output or product of the process.

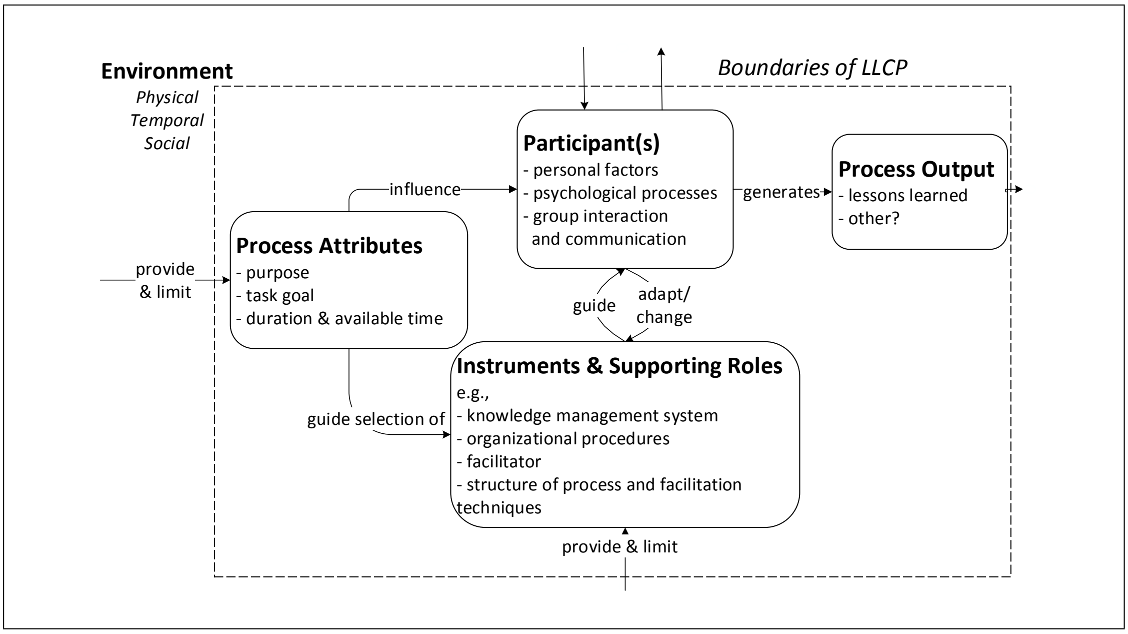

Figure 1.1: A general model of the LLCP

1.2.1 Participants

Lessons learned may be collected by individuals (e.g., Morris and Moore (2000) studied lessons learned collected by aviation pilots through a reporting system), or in group settings (e.g., in a workshop, see Baaz et al. (2010) for an example).

In general, the behavior of a person is influenced by personal and professional factors, and by psychological processes (Nolting and Paulus, 2011). Personal factors include psychological concepts such as memories (e.g., relating to the project from which lessons learned are collected), skills and abilities (e.g., to analyze experiences), but also attitudes (here defined as „a general feeling or evaluation - positive or negative - about some person, object, or issue" (Hogg and Vaughan, 2008, p.148)), personality (Nijstad, 2009; Nolting and Paulus, 2011), and other stable[2] attributes of a person such as their gender. Professional factors include the role of a person in an organization (their job), and their professional expertise.

Personal or professional factors are generally formed in the environment, but can change during a collection process. For example, participants may learn during the collection process (see also Section 1.2.2 on the next page), or they may change their attitude towards collection processes, e.g., due to a first personal experience with a

[2]Stable in relation to the lessons learned collection process. These factors typically do not change with the developing situations during the collection process.

LLCP (see also Hogg and Vaughan (2008, p.170) on the role of direct experiences for forming attitudes).

Psychological processes include emotion, motivation (which can be understood as „die aktivierende Ausrichtung des momentanen Lebensvollzuges auf einen positiv bewerteten Zielzustand" ((Rheinberg (2002), as cited by Rheinberg and Vollmeyer (2011)), and thought processes (Nolting and Paulus, 2011). In turn, thought processes of individuals include processes for the understanding of and reacting to a situation at hand (Nolting and Paulus, 2011), decision making (e.g., Klein (2008)), as well as counterfactual thinking (thinking about what might have been) (Kahneman and Tversky, 1982; Morris and Moore, 2000; Roese, 1997).

In contrast to personal factors they are less stable, and dependent upon the situation at hand (Nolting and Paulus, 2011), which changes during the collection process. The psychological processes also influence each other (Nolting and Paulus, 2011), and are influenced by personal and professional factors (e.g., expertise can influence problem categorization (Chi et al., 1981) and strategies for problem solving (Larkin et al., 1980)).

In group settings, individuals contribute to the communication and interaction in the group. In turn, they are influenced by what other group members contribute (Nijstad, 2009). Group interactions may result in *process gains* (e.g., when the group is able to derive a solution to a problem by combining the expertise of the group members, while each individual on his or her own does not have the expertise to develop a solution) or *process losses* (e.g., when a group decides to adopt a bad or incorrect solution, even though one group member provided the right solution) (Nijstad, 2009).

1.2.2 Process Output

A LLCP results in a process output (i.e., an artifact or outcome produced during a process). For LLCPes, the process output includes the documented lessons learned (Gibson et al., 2007) as well as changes in the participants, e.g., individual learnings resulting from sharing of tacit knowledge during the LLCP (Koners, 2005), changes related to affect such as satisfaction with the output, or changes in group cohesion (Nijstad, 2009). In this context, satisfaction can be understood as an affective reaction reflecting the participant's attitudes[3] towards the outcomes of a process (e.g., the collected lessons learned) *after* it happened (based on Brown et al. (2002)).

This thesis focuses on documented collected lessons learned as the primary process output. Nevertheless, oral lessons learned (or parts thereof) might be shared during the LLCP.

1.2.3 Environment

The participants do not collect lessons learned in isolation. The collection process is encompassed by an environment. Here, 'environment' is a broad concept relating to a physical, social, and temporal context of a LLCP.

[3]In general, the first experiences with an attitude object (e.g., the concept of a lesson learned, or LLCPes) can form a participant's attitude towards this object (Hogg and Vaughan, 2008, p.148), which in turn might influence emotions and future behavior towards that object (see Ajzen and Fishbein (2005) for a general discussion of the influence of attitudes on behavior).

The physical context includes the location in which the participants collect lessons learned. LLCP can take place in meeting rooms, external training centers, but also more informal locations such as pubs (Koners, 2005).

The temporal environment positions the LLCP in relation to other events, situations, and processes, and includes the past and future of participants, instruments, and individuals in supporting roles. Most commonly, LLCPes are positioned in relation to the project (at the end of the project, during a project, a specified time period after project completion (Gibson et al., 2007; Koners, 2005; Schindler and Eppler, 2003), or continuously throughout a project (Tan et al., 2010)), or project milestones (Gibson et al., 2007). Alternatively, LLCPes can be positioned in relation to the experiences that form the basis for the lessons learned. For example, lessons learned can be collected in retrospect (also called „in hindsight", see Busby (1999)), or while the experiences are still ongoing (which Weber et al. (2001) called pro-active collection).

The social context deals with, e.g., coworkers, support from management, and the organizations involved in a project, as well as the organizational, national, and professional cultures influencing participants (see also Ajmal et al. (2009) on the culture of a project).

Environmental factors may cover several of these dimensions. Previous encounters of participants with coworkers' attitudes regarding lessons learned cover both temporal and social aspects, for example. Similarly, extant knowledge management efforts in an organization may cover all three dimensions.

The environment influences the participants: the social environment (Hogg and Vaughan, 2008, p.172–174) and personal experiences (history of participants) shape the participants' attitudes and memories, for example. In turn, the environment is influenced by the participants (Nolting and Paulus, 2011) (e.g., through applied personal learnings). Furthermore, the documented lessons learned may influence the environment (e.g., if the lessons learned are applied in future projects).

1.2.4 Instruments and Supporting Roles

In this thesis, instruments are defined as s a means to support an aim related to the collection of lessons learned. Instruments and supporting roles (e.g., a facilitator Liebowitz (2008)) are used with the intention to contribute to the goal of collecting lessons learned. Several, very diverse, instruments can be found in literature for supporting the collection of lessons learned. For example, Schindler and Eppler (2003) provide an overview of several documentation-based methods, i.e., methods focusing on the „contentwise representation of experiences and the storage of contents". Collier et al. (1996) used surveys as part of their process, while Carrillo et al. (2013) found that post project reviews (which are centered around meetings (Koners, 2005)) and face to face meetings with the project team were considered to be the most informative and the most used instruments to collect lessons learned among UK construction companies.

Others explored ICT aspects, and suggested using web 2.0 technology such as wikis or blogs to support lessons learned efforts in organizations (Chaves and Veronese, 2014; Petter and Vaishnavi, 2008; Wiewiora and Murphy, 2015).

The behavior and communication of the participant(s) can be influenced by these instruments or individuals in supporting roles. Collier et al. (1996) used surveys as part of their process, while Carrillo et al. (2013) found that post project reviews (which are centered around meetings (Koners, 2005)) and face to face meetings with the project team were the most informative and the most used instruments to collect lessons learned among UK construction companies.

Instruments can also have a direct relationship to the collected lessons learned. For example, a template (as a documentation-based method) can be used to structure a lessons learned (Liebowitz, 2008).

The instruments typically originate in the environment, but individuals and groups may be able to influence, interpret, adapt, or ignore some of these instruments or behavior of individuals in supporting roles during the collection process. For example, a group may request additional process steps from a facilitator, or an individual may decide to adapt a template.

1.2.5 Additional Properties: Purpose, Task Goal, and Available Time

The last group of factors concerns some additional properties of the process, e.g., the task goal or purpose of the collection process, or the time available for collecting lessons learned.

A task goal deals with the objectives that should be achieve during an activity or process. A task goal is a performance goal. If participants are aware of the task goal, it influences the behavior of individuals by directing attention and effort towards the goal, affecting persistence in obtaining the goal, and fostering the use of task-relevant knowledge and strategies (Locke and Latham, 2002). In organizational and group settings, the task goal may be in conflict with personal goals of individuals performing the task. In such conflicting situations, personal goals may actually have a detrimental effect on performance (Locke and Latham, 2002; Briggs et al., 2014).

In contrast to the task goal, the purpose addresses the question of why an activity or process is performed. For the LLCPes studied in this thesis, the general *task goal* is to elicit and document previously undocumented lessons learned, and the general *purpose* is to improve the performance of projects by repeating successes or preventing repeated negative experiences (e.g., in the form of mistakes; derived from the goal of a lessons learned in project based organizations).

Purpose and task goal may still vary between instances of LLCPes. Projects may collect lessons learned in order to improve particular future projects, for example. Similarly, regarding the task goal, a project may focus on lessons learned about project management, while another to focuses on technical lessons learned.

Another important property of a collection process frequently mentioned in literature is the time available for collecting lessons learned (see, e.g., Kotnour (2000); Keegan and Turner (2001)). Similar to the purpose of the collection process, the available time may influence the behavior of participants, e.g., because in a group setting under time pressure there will be more pressure to reach consensus quickly, and interaction patterns in groups may change (Nijstad, 2009).

Task goal, purpose, and available time may be provided or limited by the environment. The purpose of the collection process can be defined in organizational procedures, or be provided by the project manager (e.g., in informal lessons learned programs). In a similar vein, a project or line manager can limit the time participants are allowed to spend on the collection process.

1.3 Research Questions and Scope

Following the basic model, the general purpose of LLCPes in project-based organizations is to improve the performance of projects by repeating successes or preventing repeated negative experiences. However, the introduction has indicated that, even though organizations perform LLCPes, they can be ineffective in collecting lessons learned that are fit for this purpose.

Given these difficulties, the aim of this thesis is threefold: improving our understanding of how the outcomes of a LLCP relate to the usage of lessons learned, identifying challenges that may result in missing or difficult to use outcomes of LLCPes, and then investigating how instruments in LLCPes shape outcomes of a LLCP.

First, it is important to understand which factors associated with lessons learned enable them to be used for their purpose. This leads to the following Research Question (RQ):

RQ1 When are the collected lessons learned fit for their purpose?

Collecting (useful) lessons learned is not an easy endeavor, as evidenced by the struggles of organizations in collecting lessons learned, leading to the following Research Question:

RQ2 What makes LLCPes challenging?

Research Question **RQ2** aims to develop a broad understanding of these challenges in that the challenges may be associated with all elements of the basic model of a LLCP (including its environment). However, the scope of Research Question **RQ2** is limited in that only challenges focusing on LLCPes (and not those of knowledge management in general) are considered.

Instruments used in LLCPes are not necessarily equally effective in guiding participants when collecting (useful) lessons learned. Perhaps some instruments address a particular challenge, while others do not. This could result in changes in characteristics of the lessons learned. Also, some instruments might guide participants to collect lessons learned that have a better fit with an envisioned usage process than others. This leads to the following Research Question:

RQ3 How do instruments shape the resulting lessons learned?

These three questions cover a broad area of research: they include learning from a single safety incident as well as traditional post-project reviews, and encompass various project-management process and cultures. The LLCPes and the use of lessons learned may vary considerably in these research settings.

In general, this thesis aims to learn about large multi-national organizations operating from Western Europe, and in the oil and gas industry. Project management in this industry incorporates standard practices outlined in PRINCE2 (Bentley, 2010) or the PMI body of knowledge (Project Management Institute (PMI), 2004), and, in the personal experience of this researcher, participants in LLCPes (including project managers) often have an engineering background.

The maturity of the lessons learned processes influences how well LLCPes (and other lessons learned processes) perform, and whether the resulting lessons learned are consistently used (Gibson et al., 2007). It ranges from the informal (organizations performing lessons learned processes sporadically) to the formal (organizations performing lessons learned processes as part of recognized work processes supported by a consistent methodology (Gibson et al., 2007)). As organizations employing informal lessons learned processes have a higher interest in improving their situation, this thesis focuses on informal LLCPes for Research Question **RQ1** on the facing page.

Studies of LLCPes can be further delimited through the type of instruments and supporting roles used. This research aims to create insights on collaborative LLCPes (e.g., a post-project reviews or face-to-face meetings) facilitated by an external (to the project team) facilitator, because such LLCPes are considered both informative and useful (see also Section 1.2.4 on page 10), and organizations with no LLCPes or only informal ones may find it easier to change their facilitated LLCPes than to adopt custom-made IT support for lessons learned.

In addition, the LLCP should allow the organization to learn from success, mistakes, and routine events. In particular, the purpose of the LLCP should not focus on something out of the ordinary such as a safety incident.

The research results are intended to inform future designs of LLCPes (particularly for helping organizations with low collection efforts to adopt the collection of lessons learned) and create a foundation for future (quasi-)experimental research comparing different approaches to collect lessons learned.

1.4 Research Philosophy and Design

1.4.1 Philosophical Foundations

Philosophical assumptions about reality (ontology) and knowledge (epistemology) are the foundation of any research endeavor. Research on lessons learned in particular, and information systems in general, deals both with the physical and the social world. In the context of information systems, such research has been conducted using varying philosophies (Mingers, 2004). This section presents two of the most common paradigms: positivism and interpretivism. Critical realism is a third paradigm, suggested by Mingers, that forms the foundation for this research.

Positivism in various forms (e.g., logical positivism and post-empiricism as proposed by Popper) is underpinning most of information systems research (Mingers, 2004). These philosophical streams follow a realist ontology – reality and things in the world have an objective existence independent of an observer (Danermark et al., 2002). Logical positivism holds that our senses provide direct, unproblematic access to this reality, and theories are derived from facts using inductive reasoning (Chalmers, 1999).

In contrast, post-empiricism (called falsificationism by Chalmers (1999)) assumes that any observational statement of the physical and the social world is theory-laden (i.e., it is influenced by theories and ideas). Also, it stresses the critical role of science: theories should make predictions about observations that can be tested through observations or experiments (Chalmers, 1999). Both streams of research posit that the physical and the social world can be described through law-like generalizations, and explaining means deducing particular events based on these laws and a set of antecedents (Mingers, 2004).

Conversely, interpretivism is even more diverse. Ontologically, extreme strands of interpretivism deny that social objects such as organizations exist independently of the human mind (following an idealist ontology) (Mingers, 2004). The physical reality is conceived as not directly accessible to scientists (Chalmers, 1999). Consequently, knowledge about the social world is dependent upon cultures, actors, and social practices, and both the actors in an event and the researcher interpret the social phenomenon (Mingers, 2004).

Both paradigms were not used in this research. The interpretivism because of the underlying ontological assumptions and its subjectivity, which may make it difficult to differentiate between competing claims to truth (Easton, 2010; Patomäki and Wight, 2000), and positivism because it either denies the role of theory for observational statements, or, in the case of falsificationism, because it would have rejected major scientific theories early on (see Chalmers (1999) for some examples from physics).

Mingers suggested using a third paradigm for information systems research that addresses some of these issues: critical realism. Critical realism combines ideas from positivism and interpretivism. It assumes that the physical and the social world exist independently of observers (Easton, 2010), and are knowable through research, albeit imperfectly. Critical realism acknowledges that the knowledge of the world is concept dependent, and theory-laden (Sayer, 1992). "Social phenomena, such as actions, texts, or institutions" (Sayer, 1992, p. 6) are considered concept dependent and are interpreted from the researcher's own "frames of meaning" (Sayer, 1992, p. 36), but, unlike interpretivism, critical realism argues that social phenomena exist independently of the researcher's interpretation of them (Sayer, 1992).

This research is based on critical realism, because it matches the personal assumptions of the researcher. In particular, critical realism acknowledges that it is possible to know the real (social) world. It also rejects falsificationism as an appropriate approach for research in an *open* system.

This choice has some implications. First, critical realism proposes that reality is structured. The world consists not just of events (something that happens[4] including external and visible behavior or developments) but includes objects/entities (e.g., organizations, actors, attitudes, relationships, or ideas of something) having causal powers (an entity enables, produces, determines, or has a tendency for something) and liabilities (being susceptible to the causal powers of other entities) (Sayer, 1992), which can generate the events (Mingers, 2004). Entities are structured, i.e., they consist of "a set of internally related objects or practices" (Sayer, 1992, p. 92).

Second, it is the purpose of research to explain events in terms of these structures and conditions – identifying patterns (e.g., linear relationships between variables) may indicate that there are structures at play, but the identification of such relationships is a first step, and not the ultimate goal of research. The transfer of results from closed systems (e.g., structures identified or confirmed in experiments) to open systems involves the assumption that these structures and causal powers are present in open systems as well (Danermark et al., 2002).

[4]Please note that this notion of an event is not limited to something that is important or instantaneous.

Last, critical realism posits that in social systems these structures, while they are real, may not always be active, and, even if they are active, their influence may not always create regular, observable patterns (Mingers, 2004).

1.4.2 Research Design

A research design should describe how to get from the research questions to conclusions answering these questions (Yin, 2008).

In general, critical realism is not committed to a single form of research for gaining knowledge (Mingers, 2004). Rather, critical realism accepts that different research objects require different research approaches (Sayer, 1992). Because different types of entities can interact with each other, it is to be expected that a variety of research methods need to be used for gaining knowledge (Mingers, 2004).

In order to advance the knowledge about the structures and dynamics of LLCPes, the characteristics of the resulting lessons learned, and their connection to usage processes, lab-experiments and field research (in the form of case research) were considered. (Lab-)Experiments are studies performed in a designed, controlled environment. They aim to isolate cause and effect, and to eliminate alternative explanations for the observation they produce (Coolican, 2013). Their strength is that certain mechanisms (particularly in the natural sciences, but also in psychology) can be studied in their pure form (Danermark et al., 2002). In contrast, field research involves studying the LLCP in real life. It includes case studies, which aim to study the research subject as a relatively unconstrained, natural phenomenon (Yin, 2008), and action research, which aims to foster change in the studied organizations and focus on planned interventions (e.g., manipulations of the instruments used to collect lessons learned) in real life situations. These methods are characterized by the varying degrees of influence over the process (ranging from no influence in case studies to carefully controlled experiments) and their immersion in real life situations.

Both lab-experiments and case research have been considered as a methodological foundation for research that is based on critical realism (Danermark et al., 2002; Easton, 2010). Case studies are better suited to gain knowledge in open systems (Danermark et al., 2002).

Characteristics of the environment in which lessons learned are collected indicate that LLCPes are indeed open. Experiences in projects form the basis for the collected lessons learned. They are temporary organizations with non-routine features, characterized through complexity and uncertainty (Williams, 2008). Lessons learned can rely on past problem solving processes (Disterer, 2002), which differ across disciplines and levels of expertise (e.g., Sternberg (1995)). The situation is exacerbated as project team members have various professional backgrounds, including various levels of expertise. Also, past experiences with lessons learned collection processes may influence participant behavior. Thus, both professional cultures (Ajmal et al., 2010) and the participants' knowledge and experiences may influence what happens during the LLCPes, and subsequently the resulting lesson learned.

These characteristics of the environment make it difficult to approximate realistic settings in a controlled lab-experiment (which would also require comparable projects as the basis for the experiences), resulting in a threat to transfer conclusions of this research to real-life LLCPes. For these reasons, this thesis used case research with varying degrees of control to study LLCPes in real-life situations.

The case research was complemented by literature studies for (a) defining and framing the data collection and analysis performed in the case research, and (b) for comparing, contrasting, and synthesizing findings from literature and this research on the three research questions. Regarding the latter, a combination of field research and literature study was deemed necessary as approaches for collecting and using lessons learned are designed interventions. As such, they can be redesigned, e.g., as a reaction to challenges, positive experiences with LLCPes, published research, and consultancy work, leading to continued change.

1.4.2.1 Unit of analysis

One component of the design of case studies in particular (see Yin (2008)), and case research in general, is the conceptualization of the unit of analysis (i.e., defining what the case is).

The unit of analysis is related to the question of what a case is (Miles and Huberman, 1994; Yin, 2008). It may be an individual, a social unit such as an organization, or events and processes (Miles and Huberman, 1994). For events or entities (such as organizations) the researcher needs to delineate the unit of analysis (Yin, 2008), while acknowledging that the boundaries are „never quite as solid as a rationalist might hope" (Miles and Huberman, 1994). It is also important to realize that the definition of the unit of analysis may develop throughout the research, and that a case may contain several embedded units of analysis (Yin (2008) has argued this for case studies). The following points help to define the unit of analysis:

- the unit of analysis is related to the research questions, and should be some real-life phenomenon (not an abstraction) (Yin, 2008)
- the boundaries of the unit of analysis can be further defined by stating what will not be studied (Miles and Huberman, 1994)
- the boundaries of a case can be defined by considering specific dimensions of the case: temporal and spatial extent, social size, conceptual nature (Miles and Huberman, 1994)
- in order to compare findings with previous research, key definitions should not be idiosyncratic but be either similar to those previously studied or distinguishable in operationally defined ways (Yin, 2008)
- the unit of analysis is further defined through the sampling criteria (Yin, 2008)

The case boundaries vary for the three research questions. Figure 1.2 on the facing page provides an overview of the relationships relevant for this research. Regarding Research Question **RQ1** on page 12 on the usage of lessons learned (U_{Org} and $U_{Project}$), the unit of analysis is any processes or practices for using lessons learned. In this research, these units of analysis are studied in an organizational (O_{Case}) and (optionally) a project context (P_{Using}). Regarding Research Question **RQ2** on page 12 on challenges for LLCPes, the unit of analysis is an organization O_{Case}, with individuals reporting on

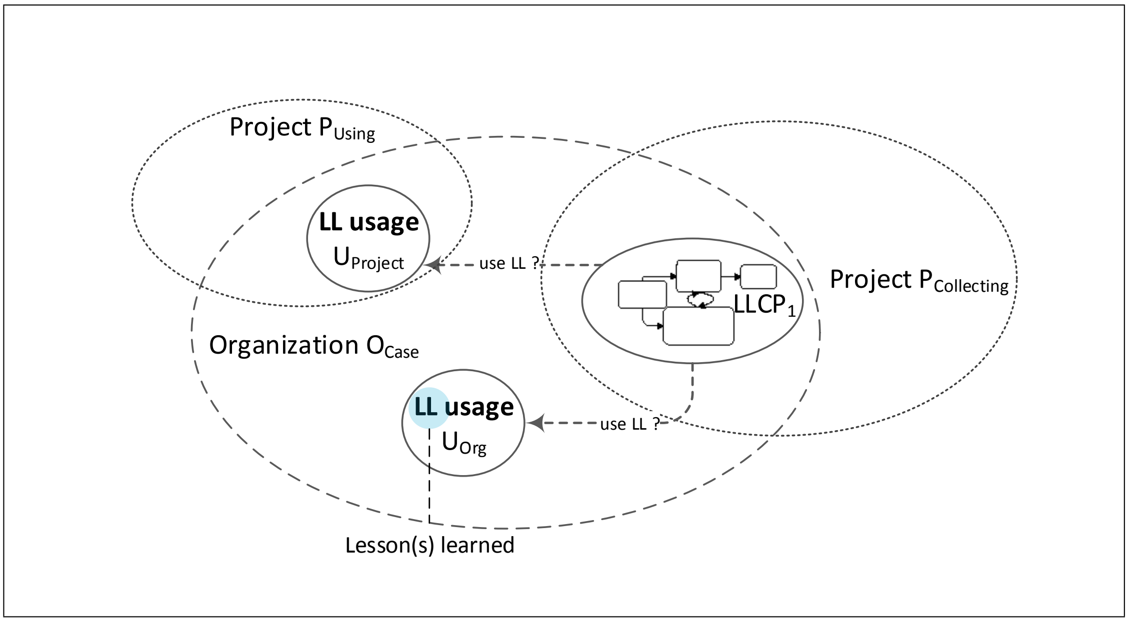

Figure 1.2: Unit of analysis

these challenges as embedded units. Last, regarding Research Question **RQ3** on page 12 on instruments shaping LLCPes, the unit of analysis is a LLCP (LLCP$_1$), which creates lessons learned (or drafts thereof) as its output. A LLCP is assumed to be associated with at least one organization O_{Case} collecting the lessons learned, and at least one project ($P_{Collecting}$) from which the lessons learned are collected. Given the industry context in which this study takes place, the projects collecting lessons learned will involve more than one organization though these other organizations may not be involved in the LLCP. This research will not study completely dysfunctional LLCPes, or processes that do not produce *written* lessons learned.

Lessons learned resulting from a specific LLCP (LLCP$_1$) may (or may not) be the input for a specific usage process, thus creating a tenuous relationship between collecting and using lessons learned. This relationship may allow studying the usage of particular lessons learned for **RQ1**, and create insights into the quality of a lessons learned for **RQ2**.

One factor not considered in this research are any processes or practices that take place between collecting lessons learned and using lessons learned (e.g., a validation processes for lessons learned). Such processes or practices may influence how lessons learned can be used, as they can modify a lesson learned to meet requirements of a usage process. @future{investigate adapter processes that bridge LLCPes and usage}

This delineation of the units of analysis allows this thesis to investigate several distinct processes within a single organization, and to link short-term utilization of lessons learned to the collection processes.

1.4.2.2 Case selection

Yin (2008) pointed out that case selection can use a mixture of two strategies: selecting cases with the intent to obtain similar results, and selecting cases with the intent to obtain contrasting results. Both strategies were used in this thesis. The core selection of cases was based on serendipity, and guided by the focus outlined in Section 1.3 on page 12. This core was complemented by a wider variety of cases. Due to organizational and professional cultures and their influence on lesson learned programs, the military, organizations operating in the health sector, and any organization using agile methods were excluded from the data collection.

The results of this study are intended to inform future designs of LLCPes (particularly for helping organizations with low collection efforts to adopt the collection of lessons learned) and create a foundation for future (quasi-)experimental research comparing different approaches to collect lessons learned. Therefore, access of the researcher to (sufficiently detailed) data served as an exclusion criterion. For LLCPes, access to a detailed description or observations of the process, intermediary results (if any) and drafts of the lessons learned were required.

1.4.3 Structure of this Thesis

This chapter has introduced the research problem, presented the research questions, and provided an introduction into the research approach based on case research on a high level.

Case research, as used in this thesis, further utilizes interviews, surveys, and observational studies to collect qualitative and quantitative data. An overview of on the cases as well as the data collection can found in Chapter 2 on the next page.

Next, Chapter 3 on page 33 explores the perspective of a user of lessons learned in order to obtain an understanding of when a lesson learned is fit for its purpose. The chapter explains the theoretical foundations and research design relating to Research Question **RQ1** on page 12, and then continues to present and synthesize the results drawing conclusions on usage processes for lessons learned, and characteristics of lessons learned that make them useful.

Following a similar structure, Chapter 4 on page 45 explores challenges on collecting lessons learned (Research Question **RQ2** on page 12) that LLCPes may (or may not) need to address.

The core part of this thesis presents the case research on LLCPes pertaining to Research Question **RQ3** on page 12. The theoretical framework laid out in Section 1.2 on page 7 is extended to include the temporal aspects of LLCPes in (Chapter 5 on page 67). Then, a more detailed discussion of the research design employed in the case research is presented in (Chapter 6 on page 77), followed by a detailed presentation of 8 cases on LLCPes (in Chapter 7 on page 89 to Chapter 12 on page 193).

Finally, the results are synthesized in a cross-case analysis (Chapter 13 on page 210). 13 not just compares the LLCPes studied in the cases, but also includes related work describing additional LLCPes in detail, and discusses relations to the challenges and usage scenarios identified in the second part. The final chapter consists of conclusions, and recommendations for future research.

Chapter 2

Case Overview

This chapter presents background information and characteristics of the cases used in this dissertation on collecting lessons learned. It also outlines which types of organizations and projects contributed to insights on using lessons learned and challenges and processes for collecting lessons learned.

In order to present the cases and their context, this chapter follows Section 1.4.2.1 on page 16 for outlining the context of the units of analysis. Thus, this chapter presents

- background information on the involved organizations
- key characteristics of the lessons learned processes of the organizations
- background information on the projects or organizational units collecting lessons learned
- a description of the extend of influence of the researcher on the collection process
- an overview of data sources used for the lessons learned collection processes

2.1 Introduction to Participating Organizations

Overall, four large[1], multinational organizations participated in the studies for this thesis (see Table 2.1 on the following page for an overview of the (anonymized) organizations). For one organization, its size was unknown. ConstructOrg, FoodOrg, MarineOrg, and OwnerOrg contributed to cases on *using* lessons learned. ConstructOrg and FoodOrg also contributed to challenges on collecting lessons learned. Three out of the five organizations (InnovOrg, MarineOrg, and OwnerOrg) contributed to cases on *collecting* lessons learned. For FoodOrg and ConstructOrg, the level of detail regarding how lessons learned are collected in these organizations was not sufficient to include FoodOrg and ConstructOrg in the case studies on collecting lessons learned. Nevertheless, they provided valuable insights into the usage processes as well as challenges for collecting lessons learned.

[1]Following Eurostat (http://ec.europa.eu/eurostat/web/structural-business-statistics/Structural-business-statistics/sme), this means an organizations with at least 250 employed persons (last access: 24 August 2016).

Table 2.1: Participating organizations

Name	Sector	Employees[a]	Location	Headquarters	Role in projects
MarineOrg	Oil & Gas	> 1500	Multinational	Netherlands	Contractor
OwnerOrg	Oil & Gas	> 85000	Multinational	Netherlands	Owner
FoodOrg	Food	> 75000	Multinational	Netherlands	-
ConstructOrg	Engineering & Construction	> 40000	Multinational	USA	Contractor
InnovOrg	Energy	unknown	Multinational	Netherlands	Joint Venture (Owner)

[a] Based on the annual report 2012 of the organization, or their website

2.1.1 Anonymity and Confidentiality

The anonymity of the organizations, projects, and interviewees was promised for each setting. This thesis uses aliases to allow the reader to differentiate between specific LLCPes, organizations, and interviewees. Furthermore, the content of lessons learned and events in the project had to be treated confidentially. In order to handle this limitation, specific lessons learned are only described in a very general way when needed.

2.2 Introduction to Cases about LLCPes

The cases for collecting lessons learned were researched in the context of projects or sub-departments of an organization. Table 2.2 on page 22 maps these cases to their respective organizations. To distinguish between projects and the LLCPes conducted in these projects, a key word describing the case (e.g., „Deepwater") is combined with the suffixes „Project" for the project, and „Col"(lection) for the LLCP. If a project or department conducted more than one collection process, roman numerals are used to enumerate the instances.

The following sections outline variations in data availability and influence of the researcher on these cases.

2.2.1 Data Sources

Case research is characterized by a mixed availability of data sources. Data sources used in this thesis include documents, software artifacts, and people. Yin (2008) suggests including documents in any data collection plan for case studies. Documents are any materials that can be read (with an understanding of reading that encompasses the interpretation of visual materials such as diagrams) (Bryman and Bell, 2007). Software artifacts as data sources are similar to physical[2] artifacts. Software artifacts of interest for this thesis are those used to support a collection process, and include knowledge management systems or lessons learned repositories. Last, this thesis used three types of research instruments to collect data from people.

[2] See Yin (2008) for a discussion of physical artifacts as data sources.

Interviews are one of the most important data collection methods in case studies (Yin, 2008). This thesis employed mainly semi-structured interviews, which can be considered as a guided conversion: while they have a consistent line of inquiry guided by an interview guide, they still encourage „going off at a tangent" (Bryman and Bell, 2007) to follow emerging themes. Such interviews are best suited to explore subjective intentions, opinions, and perceptions of an event or entity (rather than the event or entity itself) (Bryman and Bell, 2007). To a lesser extent, they can be used to gather factual information on events and situations that happened over an extended period of time (Bryman and Bell, 2007).

Observational methods are another way to collect data in case studies (Yin, 2008) and business settings (Bryman and Bell, 2007). These methods deal with actual behavior of people and, if conducted in a field setting, entail the researcher observing unconstrained (by laboratory or other artificial settings), freely chosen behavior of a group as the behavior occurs (Coolican, 2013). As such, observational methods are an effective means to gather data on the setting and on overt behavior encountered during a facilitated lessons learned collection process.

Surveys (also called self-completion questionnaires (Bryman and Bell, 2007)) are a means to gather data from people at a point in time (Cohen et al., 2011), e.g., after an event such as a pilot phase or a lessons learned collection workshops. They are useful for acquiring factual information as well as subjective perceptions (e.g., data on experiences, attitudes, beliefs and opinions) that can span both past and present (Cohen et al., 2011). Because they are quick to administer and can be filled out when a respondent has time (Bryman and Bell, 2007), they are suitable to gather quantitative data from a larger group of people. In the context of a case study, they can be used as part of an *embedded* case, e.g., for assessment purposes (Yin, 2008). As a result they may provide only one component of the overall assessment (based on Yin (2008)). In other words, some triangulation with other data is possible in case studies.

Table 2.2 on the following page summarizes the data sources and the data collected from these sources for each case.

The collected data was mainly used to (1) derive descriptions of how lessons learned were collected in the cases, and (2) to assess the quality of these processes. Regarding the first objective, the descriptions were derived from direct observations of the process, or from automated recordings of the participants' communication. Only for one case (TerminationCol), the process description had to be derived from official reports and interviews with the facilitator of the lessons learned process. For the majority of cases, the data was complemented with insights from the designers of the process.

Regarding the second objective, the quality assessment relied on surveys investigating the perception of participants regarding the process and its outcome, on an assessment of the final lessons learned by the researcher, and on interviews about how the final lessons learned were used (or not).

Table 2.2: Collecting LL – Data used for each case

		InnovOrg	**MarineOrg**				**OwnerOrg**
Data Sources	**Data Types**	**InnovProject**	**Deepwater Project I & II**	**DepartmentCol**	**RepositoryCol**	**Termination Project**	**RefineryProject**
Documents	*Supporting Material (e.g. slides)*	Yes	No	No	Yes (inspection of ICT tool)	Partially (as part of report)	Yes
	Intermediary documents generated during collection process	Yes (including extensive minutes of discussion in GSS)	No	No	No	Yes (as part of report)	Yes (including extensive minutes of discussion in GSS)
	*Final LL**	Yes (public version only)	Yes	Yes	Yes	Yes (as part of report)	Yes
People Observations	*Notes*	No	Yes	Yes	No	No	Yes
	Audio recording & transcripts of interviews and meetings	No	No	Yes (no transcript)	No	No	Yes
People Interviews	*Transcripts, Recordings, Notes*	Facilitator	Responsible KM	Facilitator	Designing KM	Facilitator	Program Manager
People Survey	*Quantitative Data*	Yes	No	Yes	Yes	No	Yes
	Qualitative Data	Yes	No	Yes	Yes	No	Yes
Artifacts	*Notes, Screenshots*	No	No	Yes	Yes	No	No

* LL submitted for validation or for final storage

2.2.2 Level of Influence

The studied lessons learned collection processes are characterized by a varying level of influence or control that the research had on the design and evaluation of the lessons learned collection process. They include lessons learned collection process without any influence (e.g., in DeepwaterCol I & II), which means these cases are case studies as defined by Yin (2008). In contrast, RefineryCol was designed as part of this thesis (and implemented by research colleagues). This means the research resembles a design science study more than a typical case study.

Following practices from action research as outlined by Narayanaswamy and Grover (2007), the case descriptions account for control issues associated with a non-observational study by clarifying

1. who initiated the research
2. the degree of formalization (formal, informal, emerging)
3. the role of researcher - what was the level of influence?
4. the need for the researcher's influence
5. questions of authority (who exercises authority over planning, designing, and implementing actions?)
6. whether the client approved actions.

Questions 1 and 2 address how access to an organization or project was established, and are therefore answered for every case. The other questions are specific for cases where the researcher had some influence on the design or evaluation of lessons learned collection processes. These questions help to judge the involvement of researcher and participants in the studies, and thus increase the validity of the research (Narayanaswamy and Grover, 2007). Table 2.3 on the next page provides an overview of the degree and type of influence in the various collection processes. Details regarding the influence of the researcher are described in the following sections.

2.3 Collecting Lessons Learned – Case Background[3]

This section contextualizes the research on lessons learned collection processes. It provides an overview of the status of lessons learned processes in the various organizations (see also Table 2.4 on page 32). It also outlines the collection processes within their projects or departments. Last, it provides an overview of the data available for each lesson learned collection process.

[3]Parts of this chapter were based on Buttler and Lukosch (2012, 2013).

Table 2.3: Collecting LL – Influence of researcher on process design

Organization	Case	Influence on LL Collection Process	Timing of Influence	Comment
InnovOrg	Innov Project	No	-	There was no direct influence, but the facilitator for the LL collection process was also involved in the prior RefineryProject.
MarineOrg	Deepwater Project I	No	-	
	Deepwater Project II	No	-	
	Department Col	Yes (provided facilitator with a description of the process employed in DeepwaterProject I & II)	During preparation of LL collection effort	The influence enabled the facilitator to develop a process design very similar to Deepwater I & II
	Repository Col	Yes (discussions of designed software application, and communication of bugs)	Before implementation of software application (for feedback), and during pilot phase (for bugs)	
	Termination Project	Potentially (discussion of how to handle extant LL collected by project members)	During preparation of LL collection effort	It is unclear whether these discussions had any impact on the design.
OwnerOrg	Refinery Project	Yes (design of the whole LL collection process)	During the whole LL collection process	This case follows design science research.

2.3.1 MarineOrg

MarineOrg started formalizing their lessons learned processes in 2011, following a Master of Science (MSc) thesis at TU Delft (Barney, 2011). As part of her thesis, Barney (2011, pp. 51) found that the value of lessons learned had been recognized at MarineOrg. Nevertheless, knowledge sharing occurred mainly informally through personal contact, and not through documented lessons learned. Even though existing procedures in MarineOrg mandated projects to collect lessons learned as part of the project close-out, these procedures did not require a separate process for collecting lessons learned, nor did they specify lessons learned or a process to collect them. Furthermore, there was no central system focusing on the storage and retrieval of lessons learned. As a consequence, each project team applied their own definition of a lesson learned (and its components), and used their own process to obtain them. In addition, the quality and quantity of the collected lessons learned varied considerably between projects. More precisely, the content and format of lessons learned were often not suitable, the collected lessons learned varied with regard to their specificity (being often too specific or to general), and were difficult to understand (Barney, 2011, p. 57).

Considering these difficulties, Barney (2011) suggested technological improvements, as well as design implications for the institutionalization and monitoring of lessons learned. Several of these suggestions were implemented in a pilot study on introducing and formalizing lessons learned practices in MarineOrg, and on developing computer support for these practices. The research outlined in this thesis occurred during the planning and execution of this pilot study. Barney facilitated access to these lessons learned efforts (including all cases used in this research), and helped to formalize the agreement. The actual scope of the research at MarineOrg grew from an evaluation of the piloted application to include observational research in DeepwaterCol I & II, and descriptive research in TerminationCol.

2.3.1.1 DeepwaterCol I & II

DeepwaterCol I & II are observational studies of lessons learned collection processes. The lessons learned collection processes were conducted in the context of a large project (the DeepwaterProject), with MarineOrg as the main contractor. This project involved several subcontractors and vendors. For MarineOrg, this project was novel with regard to the size of the project, and with regard to the role of the organization. The project contained the option to follow up with similar projects with the same client. In order to prepare for this possibility, MarineOrg was bound by contract to collect lessons learned at the end of the project.

Due to the size of DeepwaterProject, the collection of lessons learned occurred in several workshops, each focusing on a specific theme. Overall, there were over 20 themes discussed in several lessons learned workshops. This thesis reports on two of these workshops. Even though both lessons learned collection processes were very similar, they still show small differences in the way the processes were guided. Therefore, they constitute two different cases, which are described together in Chapter 7 on page 89.

In this thesis, DeepwaterCol I & II contribute to insights on collecting lessons learned only, as the lessons collected from the associated project have not been used yet at the time of the study.

Available data The main data source for these cases is the actual observation of the two workshops, one focusing on a technical theme, the other focusing on supply chain management. It was not possible to record the workshops, because of the sensitivity of the collected lessons learned. A first draft of the collected lessons learned was used to assess the quality of the collected lessons learned, and an interview with a knowledge manager of MarineOrg provided insights into why the lessons learned had not been used yet.

In addition, it was not possible to gain feedback from participants regarding the quality of the LLCP or the resulting lessons learned. However, DepartmentCol used a similar LLCP that was assessed by the participants. Overall, DeepwaterCol I & II focused on the activities and techniques used to collect lessons learned.

2.3.1.2 DepartmentCol

DepartmentCol is a mainly observational case focusing on collecting lessons learned in a workshop. It took place in a sub-department of MarineOrg, and did not focus on a single project.

The lessons learned collection process was designed after, and heavily influenced by, observations[4] made in DeepwaterCol I & II. The facilitator of DepartmentCol took the decision to use a collection process similar to that in DeepwaterCol I & II.

The resulting lessons learned were stored and disseminated through a lessons learned repository (see also RepositoryCol Section 2.3.1.3).

In this thesis, DepartmentCol contributes to insights on collecting lessons learned. It provided an opportunity to observe the transfer of a lessons learned collection process from a project environment to a departmental environment. Furthermore, it provided the opportunity to assess the perception of the resulting lessons learned through the participants.

Available data The main data source for the lessons learned collection process is the observation of the workshop (including an audio recording). A first draft of the collected lessons learned was used to assess the quality of the collected lessons learned, and an interview with a knowledge manager of MarineOrg provided insights into why the lessons learned had not been used. Furthermore, the perceived quality of the lessons learned was evaluated through a survey (together with the evaluation of RepositoryCol).

2.3.1.3 RepositoryCol

RepositoryCol was a case study conducted in the context of the pilot study at MarineOrg. It focused on collecting lessons learned by means of a lessons learned repository. This repository was used for several months by an engineering sub-department of MarineOrg (see Table E.7 on page 285 for a more precise timeline). The lessons learned repository was designed based on the technical guidelines suggested in (Barney, 2011).

RepositoryCol was the only documentation-based method for collecting lessons learned included in this thesis, creating a contrast to the other cases, which focus on the design of processes for collecting lessons learned.

The researcher influenced this case by discussing the design of the application with the responsible knowledge manager at MarineOrg in several meetings. The knowledge manager took the decisions on which feedback to incorporate into the software. Furthermore, the researcher conducted an evaluation of this study as part of an independent evaluation of the pilot study.

Overall RepositoryCol provides a contrast to the other cases on lessons learned collection that serves as a baseline for comparisons. Furthermore, it allowed an evaluation of the perceived quality of the lessons learned repository.

Available data Data for this case included access to the repository and its functionality during the pilot study, documents describing the intended functionality of the application, daily exports of lessons learned maintained in the repository, as well as interviews with the responsible knowledge manager. A survey provided some insights into how the participants perceived the quality of the repository and the lessons learned within it.

[4]This includes observations made by the researcher as well as by the facilitator of DepartmentCol.

2.3.1.4 TerminationCol

This LLCP was conducted in the context of an ongoing project, the TerminationProject. MarineOrg has been the main contractor for the project. In addition to MarineOrg, the project involved MarineOrg's main contractor as well as at least four other subcontractors or vendors. The TerminationProject was divided into several campaigns (see Figure 2.1 for the structure of the project). Each campaign was planned for one year. The campaigns shared several high-level similarities: they had similar construction jobs and contractors, and they took place in the same oil-and gas field. During a campaign, the actual construction job was further divided among several teams.

At the end of a campaign, the project collected lessons learned. This case focuses on a lessons learned collection process conducted at the end of the second campaign. Due to the similarities of the campaigns, this project provided an opportunity for MarineOrg to gradually improve their campaigns, and to assess whether their lessons learned process had the expected effect.

Therefore, TerminationCol contributes not just to insights on collecting lessons learned, but also to insights on how these collected lessons learned were used to improve the next campaign[5].

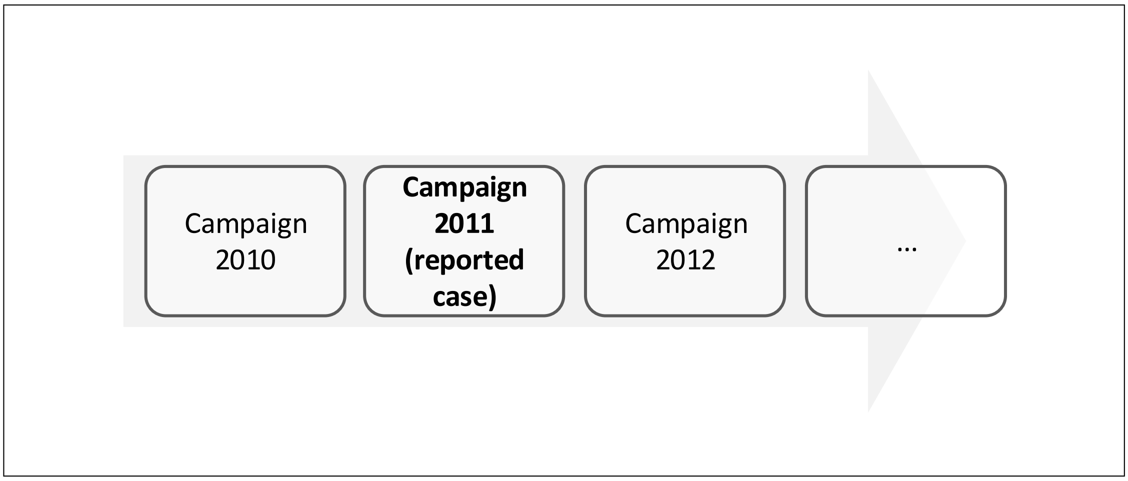

Figure 2.1: Basic project setup (TerminationProject)

Available data and limitations The main data used in the TerminationCol case were a spreadsheet and a report of the lessons learned collection process. Both documents outlined the steps taken during a workshop as well as the intermediary and final results of the workshop. Interviews with the process designer were used to confirm the main activities performed during the workshop, to gain insights into the context of the project, and to explore how the results of the collection process were used in the organization.

It was not possible to observe the collection process, or to gain feedback from the participants. These limitations have implications for the depth of the analysis of the lessons learned collection process. The available data was limited to the intended techniques, but provides little insight into the actual discussion. Furthermore, the preparation activities were inferred from the input used for this workshop.

[5] Sharing lessons learned between campaigns in the TerminationProject may be similar to sharing lessons learned between similar projects.

2.3.2 OwnerOrg

In *OwnerOrg*, the access to the case described in this thesis built on previous research in the organization about utilizing storytelling for knowledge elicitation (Buttler et al., 2011). Following this research, a program manager initiated an official project on collecting lessons learned from a specific project.

OwnerOrg had recognized that lesson learned processes enhance the performance of projects implementing LL practices. As a consequence, collecting lessons learned was a mandatory practice for projects. The resulting lessons learned were usually documented and distributed in a report.

Nevertheless, the lessons learned processes at OwnerOrg were considered to have room for improvement. The extant lessons learned practices focused heavily on „knowledge that has been documented and 'signed off"'[6]. One of the biggest challenges in OwnerOrg was the access restrictions surrounding lessons learned reports, with the risk that lessons learned might not be retrievable within the next project. Consequently, at the time of this study, OwnerOrg was investigating possibilities for improving their lessons learned practices. The research in OwnerOrg was set up as part of these improvement practices.

2.3.2.1 RefineryCol

RefineryCol is a case about collecting lessons learned from a small project (the RefineryProject) at OwnerOrg. RefineryProject involved multiple stakeholders, among others OwnerOrg and a contractor handling the management and engineering part of the project. The project team regarded the project as not successful in terms of the process employed in the project. Several team members stated that at least one of the project managers played a major role in that situation.

Consequently, an external party was asked to guide the effort to collect lessons learned about project management. In addition, the client organization wanted to improve their lessons learned efforts and to explore the opportunity to combine storytelling with lessons learned. Therefore, in the context of this thesis, an approach for collecting lessons learned from this project was developed, executed[7], and evaluated in this project (see also Buttler and Lukosch (2012) for an outline of the design rationale and first results of this case).

Overall, the project presented an opportunity to research how to collect knowledge related to project management (including stakeholder management), and to explore through an interview how the resulting lessons learned had been used in the organization.

Available data The main data sources for RefineryCol were observations of the interviews and the workshop, and minutes recorded by the group support system. These provided insights into the process actually deployed in the RefineryProject.

Because this researcher was involved in writing the final report, this thesis does not directly analyze the resulting lessons learned. Instead, an interview with the program manager provided feedback on the quality and usage of the reported lessons learned.

[6] cited from the project initiation note

[7] In order to maintain objectivity, the design was executed by some colleagues.

Furthermore, a survey among the participants of the collection process provided insights into the perception of the quality of the process.

2.3.3 InnovOrg

In contrast to the other organizations, InnovOrg was a joint venture established specifically for conducting a single project. As such, it had no history of collecting lessons learned[8].

The access to *InnovOrg* was initiated by the facilitator guiding some of the lessons learned collection processes in this joint venture. The facilitator informally offered access to data about the collection process (with consent from InnovOrg), and asked for an evaluation of the process.

2.3.3.1 InnovCol

InnovCol is a case about collecting lessons learned from an innovative project (the InnovProject) in the energy sector. The project had several contractors, and it was financed (at least partially) by government and not-for-profit organizations. Collecting lessons learned was a mandatory requirement set by one of these financing organizations.

After front end engineering and development (FEED), the project conducted four workshops for collecting lessons learned. Thus, the collection process was conducted in retrospect and tied to a gate decision. Each workshop focused on a different area of the project (stakeholder management, communication, project execution, and technical aspects), and was supported by a GSS (thinktank by GroupSystems[9]). InnovCol focused on the process for collecting lessons learned about the technical aspects of the project.

Available data The data used for analyzing the LLCP and the resulting lessons learned were an interview with the facilitator, supporting documentation (particularly the slides used during the introduction of the workshop), a report generated by the group support system containing all the contributions of the participants as well as results of any voting activity, and the public lessons learned report. Internal lessons learned reports resulting from the workshop were not available. In addition to the interview and documents, a questionnaire among the participants of the workshop was used for assessing the perception of the quality of the process and the resulting lessons learned.

2.4 Challenges when Collecting Lessons Learned – Case Background

This section contextualizes the research on challenges and concerns encountered when collecting lessons learned by providing an overview on the organizational background and parts of the lessons learned programs employed in these organizations.

This thesis utilizes challenges and concerns voiced by interviewees from two organizations: FoodOrg and ConstructOrg. These organizations were selected based on

[8] The status of lessons learned process in the parent organizations was not known.
[9] www.groupsystems.com/ (Last accessed: 30 October 2013)

the accessibility of the interviewees and because they had established lessons learned processes that were used in their respective organization for years[10].

2.4.1 FoodOrg

At the time of this study, FoodOrg employed lessons learned practices only within communities for practice for the supply chain of the organization. These practices were mandatory, and considered valuable by the organization (an indication for this is that FoodOrg was preparing to transfer these practices to the whole organization).

One characteristic of FoodOrg is that learnings from practice were not labeled „lessons learned". Rather, positive experiences were shared as good practices or as feedback on existing good practices. These good practices were stored and distributed in an integrated KMS (combining among others policies, standards and procedures, and good practices, and organizing them by communities of practice).

FoodOrg collected lessons learned from projects as well as factories and departments. It employed three major processes for collecting lessons learned:

- the KMS was used to collect feedback and good practices
- auditors identified local good practices
- facilitated sessions focused on collecting and refining lessons learned

An informal interview study in FoodOrg was set up to gain an overview of the lessons learned program, and provided insights into how lessons learned are used in the organization.

2.4.2 ConstructOrg

ConstructOrg was an organization in the energy sector (including the oil and gas sector) working primarily as a contractor. It had employed lessons learned processes for about 15 years. At the time of this research, these processes were well-established, mandatory, and supported by senior management. Lessons learned were focused on explicit knowledge, encompassing both positive and negative lessons learned.

These lessons were stored in and disseminated through an *integrated* KMS combining lessons learned with standards and procedures (similar to FoodOrg). This integrated KMS was adopted after an attempt at using a dedicated lessons learned database. ConstructOrg collected lessons learned from projects using dedicated workshops as well as a template in their KMS.

Similar to FoodOrg, this research was set up to gain insights into the whole lessons learned program using an informal interview study. Access to both cases was gained by snowballing[11].

[10] FoodOrg and ConstructOrg were selected on the basis that they both claimed to have a working LL system.

[11] Miles and Huberman (1994, p. 28) defines snowballing or chaining as „identify[ing] cases of interest from people who know people who know what cases are information rich".

2.5 Using Lessons Learned – Case Background

This section shortly references the cases used for research on usage processes for lessons learned. This thesis draws on usage processes in MarineOrg and OwnerOrg that are connected to cases on collecting lessons learned in MarineOrg and OwnerOrg (see the previous sections for organizational backgrounds and cases). For MarineOrg, this thesis considers how lessons learned were used after their pilot phase, as well as how lessons learned from the TerminationProject collection process were used for the third campaign. For the RefineryProject in OwnerOrg, the usage of lessons learned from the associated project was studied.

Furthermore, this thesis draws on the usage processes employed in FoodOrg and ConstructOrg (see previous section for the organizational background).

2.6 Conclusions

Overall, the data availability for lessons learned collection processes was high and, for most cases, includes multiple data sources on the processes or practices (thus allowing for triangulation). The influence on process/practice design varied from no influence via an advisory role to the designer of the process. In order to maintain objectivity, none of the processes was actually executed by the researcher.

In this research, the sampling at the organizational and project level relied on easily accessible sites (convenience sampling), and further identified organizations and projects from earlier cases (snowballing) using the criteria outlined in Section 1.4.2.2 on page 17.

The organizations provided the general context for using lessons learned. They were similar in that all five organizations were multinational organizations, with operations in The Netherlands. With one exception (FoodOrg), all organizations were involved in the oil and gas industry. For the oil and gas industry, both contractors and owner organizations participated in the study. The status of the organizations lessons learned efforts varied considerably (see Table 2.4 on the following page for an overview). On the one hand, MarineOrg was developing their lessons learned processes (starting in 2011 with a MSc thesis suggesting a design for lessons learned processes in MarineOrg). On the other hand, ConstructOrg and FoodOrg had established lessons learned processes that were used in the organization for years[12]. As a consequence, this research draws on instances for using lessons learned from organizations with well-established lessons learned processes as well as organizations with processes that were still developing.

Because of the well established nature of the lessons learned programs in ConstructOrg and FoodOrg, these organizations were used as a basis for challenges on collecting lessons learned.

The sampled lessons learned collection processes were more homogeneous than the sampled organizations for the usage process. All collection practices were studied in organizations trying to improve their lessons learned processes. With one exception (RepositoryCol), all collection practices involved one or more workshops facilitated by project-external facilitators. Some practices took place at the *end* of a project phase,

[12] FoodOrg and ConstructOrg were selected on the basis that they both claimed to have a working LL system.

others were studied within a departmental context. The projects varied in size and task, but in all instances they were engineering projects that involved multiple stakeholders.

Table 2.4: Main characteristics of the participating organizations' LL processes

Name	IT support for LL	Accessibility of LL	Maturity of LL processes
MarineOrg	LL repository was under development. The intention was to collect, store, disseminate, and archive individual LL.	Every employee; exceptions were possible for business sensitive LL	LL processes were under development at the time of this thesis, and partially influenced by it.
OwnerOrg	System for entering, storing, and disseminating LL reports.	Access restrictions (organization was working on breaking these down)	Collecting LL was mandatory, and considered an important practice. OwnerOrg had started efforts to improve their LL practices at the time of this study.
FoodOrg	LL were collected, stored, and disseminated in an integrated KMS that also hosted organizational policies, standards and procedures, and guidelines.	Every employee	LL processes were well established and supported by organizational policies, but limited to the supply-chain of FoodOrg. At the time of the study, the organization prepared to roll out their LL processes to the entire organization.
ConstructOrg	LL are collected, stored, and disseminated through an integrated KMS that also hosted standards and procedures, best practices, and discussion forums for communities of practice.	Every employee	LL processes have been well established, supported by best practices and mandatory.
InnovOrg	(none)	Official report published on the internet	Collecting LL was mandatory due to contracts with financing organizations

Chapter 3

Using Lessons Learned[1]

This chapter aims to answer the first research question Research Question **RQ1** on page 12

When are the collected lessons learned fit for their purpose?

'Using a lesson learned' is a process that takes a lesson learned as one of its inputs, and applies it with the intent to improve the same, future or other projects. In order to achieve such an improvement, the usage process needs to result in an output that goes beyond the modification or dissemination of a lesson learned. There are a variety of ways to use lessons learned. In the construction industry organizations change working processes or apply trainings in order to achieve the goals associated with the lessons learned processes (Gibson et al., 2007). Similarly, in one case study a hospital changed a medication process to implement learnings related to the death of a patient (Tamuz et al., 2011). Thus, to answer this question, this thesis needs to develop an understanding of *how* project based organizations use lessons learned in order to change or influence the behavior of future projects. Furthermore, this question also requires an understanding of the relationship between the quality of lessons learned and characteristics of various usage processes.

In answering this question, a literature review and several interviews were conducted. The analysis of the resulting material focuses on (1) how lessons learned are used, and (2) how the usage of lessons learned relates to their content. Based on characteristics of the usage processes, this chapter presents quality criteria of lessons learned for these various processes, and draws conclusions about the characteristics of LLCPes.

During the analysis of the materials, the usage of lessons learned emerged that lessons learned can help individuals or teams with their decision making or problem solving (involving problem finding (Getzels, 1979), problem framing, and problem solving). From a bounded rational actors' perspective, decision making involves four phases (based on Simon (1977)):

1. *Intelligence phase*: identifying and understanding gaps (e.g., problems) requiring a decision
2. *Design phase*: inventing, developing and analyzing potential solutions
3. *Choice phase*: selecting a particular solution from those available

[1]This chapter has been based on Buttler and Lukosch (2013).

4. *Review phase*: assessing and evaluating past choices

Between the choice phase and the review phase lies an *implementation phase*, that, while not part of Simon's framework, may be another phase in which users apply lessons learned.

In the following, this chapter first presents the research approach in more detail, and then moves to the results of the literature review and the interviews. Next, this chapter frames the usage processes using the five phases outlined above.

3.1 Research Design

A literature study was conducted and interview materials were analyzed to explore (1) how lessons learned were used in project-based organizations, and (2) which content-related factors were relevant for the usage of a lesson learned. Regarding the second point, the studies mainly looked at barriers or issues that arise with lessons learned during the usage process.

The literature study only included results from studies that report original research on the usage or content of lessons learned. In addition, the publications needed to provide evidence that the processes for using lessons learned are actually employed in an organization, or that the content-related factors were relevant for using lessons learned.

The interview materials included interviews conducted in four of the case organizations. Table 3.1 provides an overview of the interviewees. The interviews in OwnerOrg and MarineOrg addressed how lessons learned were used in the organization or in a project conducted by the organization. In addition, they traced the usage of lessons learned from *specific* projects through questions on what had been done with these lessons learned after their collection. The interviews in FoodOrg and ConstructOrg explored the lessons learned processes of the respective organization (from collecting lessons learned via using them to archiving them). They employed semi-structured iterative questioning to investigate what happens to a lesson learned after they were collected (and after that, etc.).

The literature and the interview material were coded with regard to two aspects: (1) how lessons learned are used[2], and (2) what content-related factors of lessons learned influence their fitness for use. To analyze how lessons learned are used the usage processes were mapped to decision making activities. In order to analyze content-related factors, this research looked at issues with the content of lessons learned, as well as content-related success factors for using a lesson learned. Characteristics of the usage processes were elicited by comparing and contrasting (see Miles and Huberman (1994)) the usage processes with regard to how they are influenced through the content-related factors of lessons learned.

3.2 Results from Literature

Literature mentions several activities that organizations or individuals perform with lessons learned. This literature review finds first indications that lessons learned are used

[2]The analysis of the interviews focused on tracing the flow of LL through the various activities and storage systems till the work processes in a project were influenced.

Table 3.1: Interviewees and their organizations

Organization	Status of LL Program	Interviewees[a]	Position	Involvement with LL
		A1	Vice president for knowledge management	Responsible for whole LL program
ConstructOrg	Functioning formal LL processes	A2	Quality assurance director	Organization of LL sessions Has presented a workshop on LL in the construction industry
		A3	Knowledge manager	Collection and analysis of LL in a community of practice
FoodOrg	Functioning formal LL processes	B1	Knowledge management consultant	Involved in designing a global KMS incorporating LL Collects, analyzes, and documents good practices
OwnerOrg	Transition from informal to formal LL processes	C1	Manager of project portfolios	Provides the perspective of a project manager
MarineOrg	Introduction of formal LL program	D1	Knowledge manager	Introduction and design of LL program at MarineOrg
		D2	Senior engineer	User of LL

[a] The interviewees' acronyms are used to present the results from the interviews (see Section 3.3 on the following page)

to change two different contexts: (part of) the organization and future projects.

First, usage processes focus on changes on an ***organizational level***[3]. Here, lessons learned are used to create or update structural knowledge assets. More precisely, lessons learned are used to *change standards and working processes* (Gibson et al., 2007), or to *modify training* given to employees (Gibson et al., 2007; Birk et al., 2002). Changes in future projects result when employees use these changed working processes, or rely on their training to perform work-related activities. For these usage processes, literature does not provide any specific insights regarding the question when lessons learned are fit for their purpose.

Second, lessons learned are used as *resources* for subsequent *projects*. Here, lessons learned are stored in a central knowledge management system or database, and disseminated to end-users in future projects who use the lessons (Kasi et al., 2008; Keegan and Turner, 2001; Newell et al., 2006). In this context, Newell et al. (2006) found that project team members typically accessed these databases after encountering problems they could not solve themselves. Thus, lessons learned are used to *reactively* solve problems in a specific project.

[3] These changes may also occur in a single department or community of practice.

Major challenges for using lessons learned on a project level relate to their *transferability* to a new project. First, lessons learned are difficult to transfer when they are bound to the context of the originating project, e.g., because they contain situated knowledge (Kasi et al., 2008). Furthermore, a major obstacle for using learnings from projects is the type of documented knowledge: Newell et al. (2006) found that projects often collected product knowledge instead of process knowledge. The authors define process knowledge as knowledge about the processes that a project team has implemented to achieve their goals (including how these processes are performed, and potential causes for good or bad performance). In contrast, product knowledge is „knowledge about what [has] actually been achieved in relation to the stated goals or objectives" (Newell et al., 2006). Newell et al. (2006) suggested that process knowledge is more likely to be transferable to the next project than product knowledge. Thus, process knowledge versus product knowledge influences the probability of a lesson learned being transferable to a subsequent project.

Apart from issues with the content of lessons learned focusing specifically on the project level, literature also discusses two general quality issues that may be relevant for both the organizational and the project level. First, Schindler and Eppler (2003) found that lessons learned might not be *specific* enough for the intended usage. Second, literature considers the *understandability* of a lesson learned as a major issue. It can be defined as the ease with which a user makes sense of the content of a lesson learned. Understandability is reduced when the content of a lesson learned lacks appropriate visualization (Schindler and Eppler, 2003) or when the content of a lesson learned is too brief for understanding the context (Tan et al., 2010, p.90). A lack of context may also be the result of too generic content in a lesson learned (Schindler and Eppler, 2003).

3.3 Results from the Interviews

The literature analysis has provided a first indication that lessons learned are used in a project or organizational context. The interviews explore this distinction further. This section presents interview results relating to details about usage processes in projects, and then continues with how lessons learned are used outside a project context.

3.3.1 Using Lessons Learned in a Project Context

The results from literature tentatively indicate that lessons learned are used to reactively solve problems in a specific project. The results from the interview study support the notion that lessons learned are used to solve problems in projects.

For example, lessons learned are used to reactively *identify* and *solve gaps* (that had been problems in previous projects) in subsequent projects. In one instance (C1), a lesson learned outlined a contractor's problematic behavior, potential causes, leading indicators for this behavior, and an idea for an intervention with the potential to change the contractor's behavior. The leading indicators were used to monitor for such behavior in subsequent projects. In one subsequent project, this behavior reoccurred. Here, the idea for the intervention was implemented, which prevented a repetition of the (negative) events for that project.

Furthermore, lessons learned are used to *prevent* negative events from reoccurring. For example, one project team created awareness through the distribution of a lesson (C1) (without implementing any further interventions), thus helping actors to *identify* potentially troublesome situations. In other cases, project teams *implemented* an idea or course of action outlined in a lesson learned (C1, D1). In the TerminationProject, some lessons learned contained solutions requiring little or no adaptation for subsequent situations in the same project (e.g., 'create [x minutes] overlap in shift changes', 'contractor needs to share [specific documents]'). Other lessons learned provided ideas of what kind of solution the future project should develop (e.g., 'develop communication plan with regard to incidents', 'develop project label system [for X]'). These examples outline two usage scenarios: using a lesson learned out of the box, or using it as a starting point for developing a solution. These usage scenarios are similar with regard to their purpose. However, they vary with regard to the effort required for actually applying the lesson in a subsequent problem situation.

Finally, lessons learned are used to *evaluate* a design by checking whether there were any unanticipated problems with a design or solution developed in a previous project (D2). This way of using a lesson learned allows the actor to retrieve a lesson after the design choices have been made. In contrast, preventing problems requires the project team to retrieve lessons learned before encountering a problem (A1, D1).

Even though some lessons learned were used to develop or implement alternatives, other lessons were not fit for *preventing or reactively solving* a problem (or gap in general), because they were not *practicable* (C1). Here, the quality of the suggested alternatives proved to be of particular importance. Some lessons learned omitted such alternatives altogether, or they just provided "motherhood statements" that outlined desirable high-level goals without suggestions on how to achieve these goals (C1).

Furthermore, the *understandability* of a lesson learned is important for its usability in future projects. One interviewee criticized that lessons used inconsistent formats, so that users had to first interpret a lesson (C1), which takes time and effort. This challenge was particularly important, because the interviewee had to screen and select several lessons learned for their relevance to a particular project. However, the impact of a lack of understandability can be reduced. Two organizations (MarineOrg and ConstructOrg) have included[4] a link to a project member in their lessons learned, because "most of the knowledge is in people's heads" (A1). MarineOrg plans to use this combination of documented lessons learned associated with a reference to a project member to mitigate negative effects if a lesson learned is difficult to understand (D1). Similarly, in OwnerOrg a program manager helped to transfer a (documented) lesson learned from one project to the next. In all of these instances, the project member can elaborate or explain a lesson learned (assuming this project member is still part of the organization).

3.3.2 Using Lessons Learned outside of Projects

All four organizations have also used lessons learned for changes on an organizational level. For example, one interviewee investigated changes on how to identify and formulate project premises (C1). Furthermore, MarineOrg targeted the planning process of their projects (D1).

[4]This creates a combination of personalization and codification approaches in the context of LL.

The changes on an organizational level affected two types of knowledge assets: human and structural knowledge assets. Regarding changes to human knowledge assets lessons learned have been used to motivate making human resources available, for example (D1). Changes to structural knowledge assets include changes to documents such as good practices, standards and procedures, or training materials (Mentzas et al., 2003). Both FoodOrg and ConstructOrg have used lessons learned for creating or changing structural knowledge assets (A1, B1). Some targeted structural knowledge assets were used organization-wide across different countries and cultures (A3, B1), others only in part of the organization. In FoodOrg, for example, some documented good practices were dependent on the local conditions of a factory, and their applicability has therefore been limited to certain regions of the world (B1). After creating or changing knowledge assets, the overall goal of lessons learned processes – preventing mistakes or repeating successes – can be achieved by using these assets in a project.

Organizations employ a variety of processes using lessons learned to evoke changes on an organizational level. First, lessons learned are used to frame an initial *understanding* of a problem. In one instance, changes to guidelines or work processes were conducted informally, based on the initiative of a participant of the collection process. This participant initiated a change process by involving relevant stakeholders (whose perspective had not been considered during the collection of the lesson learned), and discussing potential approaches on how to address issues with project premises created before the start of a project (C1). It should be noted that in order for such initiatives to lead to changes of organizational procedures, the initiator needs to have sufficient influence in the organization to start this change process.

Furthermore, the interviews identified two formalized processes for taking immediate actions on lessons learned in MarineOrg. The purpose of these actions has been to change the way of working (including communication) in the organization (D1). The first process used a facilitated session to translate lessons learned into actions for changing the way of working (including communication) in the organization (D1) (see Figure 3.1 for the abstracted process). Figure 3.2 provides an example on how this process would be used to improve an internal documentation process. In MarineOrg, this process involved negotiations between stakeholders (D1), and some discussions were quite intense, revolving around the responsibilities for past actions and future implementations (D1). The resulting actions defined goals addressing a gap delineated in the lesson learned. Actual solutions for achieving these goals were designed and implemented in small internal projects, thus building on existing change processes in the organization (D1). Thus, lessons learned are used to *understand* a problem (or gap in general), and to *develop a plan* on how to address it.

The second process took the first process a step further. It went beyond the identification of actions by including a step for *developing alternatives* (D1). Regarding the example of the documentation process, the participants would e.g., discuss during the session how the documentation should be structured. In both processes, the selection of participants is important: participants need to include actors that understand the lessons learned, and actors that can represent relevant internal stakeholders (D1). In addition, some participants of these sessions needed to be able to create a „helicopter view", taking into account not just the situation of the originating project, but also the situations in other projects (D1). Similar to the first process, the developed alternatives are implemented using established organizational procedures.

In ConstructOrg and FoodOrg communities of practice were responsible for taking actions on lessons learned, mainly by updating knowledge assets (A1, B1). Knowledge managers of these communities involved relevant actors (experts, management) to determine how to change knowledge assets (A3, B1). In ConstructOrg, taking actions on a lesson learned included the identification of root causes prevalent in a lesson learned. This identification focuses on improving the *understanding* of a problem (or gap in general). Other questions focus on improving the generalizability[5] of *solutions*, so they can be applied to more than one project (e.g., by asking 'what do we want to transfer to other projects[6]?' (A1)). Improving the problem description and the generalizability of the solution was necessary only if these aspects were not addressed during the LLCP.

The interviews revealed three concerns with regard to the required content of a lesson learned. First, the usage processes differ with regard to the *solutions outlined in a lesson learned*. ConstructOrg used a root cause analysis conducted by subject matter experts to refine initial solutions for both positive and negative LL (A1). This process implies that the solution is already part of the LL. However, considering the processes developed at MarineOrg, the development of a solution may also be addressed as part of the usage process. Second, they show similarities with regard to the generalizability of solutions across projects. Both MarineOrg and ConstructOrg acknowledge that the generalizability may need to be improved during the usage process. Third, a prerequisite of using LL for updating structural knowledge assets is that a LL and the *corresponding knowledge assets* have been described on the same level of detail or abstraction (D1).

Box 3.1: Processes for updating the way of working at MarineOrg

- *Organization*: Knowledge manager is responsible for facilitating and organizing[a] the process.
- *Input*: Preliminary list of lessons learned (most of them have already been verified)
- *Preparation*: Screening and pre-selection of important lessons learned by lessons learned coordinator and manager. This step is done before the actual session.
- *Participants*: Heads of departments, managers
- *Session*: Discuss lessons learned one by one, refine them if necessary, and identify actions addressing the lessons learned. Assign actions to the participants.
- *After Session* : Participants use existing change processes in the organization to implement their actions. Monitoring through knowledge manager that actions are actually implemented.

[a]The dual responsibility of the knowledge manager may be split up in the future.

Box 3.2: Example outlining the stages for improving a documentation process (based on Box 3.1).

Improving a Documentation Process

[5]Generalizability and problem understanding can go hand in hand when generalizing means focusing on what gap several projects have in common.

[6]After updating knowledge assets the lessons learned themselves were archived (A3). At ConstructOrg, a lesson learned was available as a resource in the knowledge management system for the transition period between collecting a lesson learned and archiving it (A3).

- *Input*: Lesson learned on insufficient documentation of part of a previous project. The lesson learned stated the intended goal of the insufficient documentation, and the effects of this insufficient documentation on the previous project.
- *During Session*: Refined lesson learned elaborated (1) which documentation needed improvement, and (2) that the structure of those documents needed improvement. The refined lesson learned did not yet outline the improved structure. An action „Improve documentation process" was created.
- *After Session*: An internal project implemented the action by determining the structure and expected content of the improved documentation, and by improving any internal processes involved in the creation of the documentation. Changes were communicated within the organization.

3.4 Discussion: Understanding Lessons Learned Use from a Decision-Making Perspective

This section presents two themes that characterize[7] the usage processes and have implications for the content of lessons learned: the relation of lessons learned usage to the decision making process outlined in the introduction of this chapter, and the context that is directly affected through the decision-making process. In the following, this section discusses these two themes, and outlines variations in their requirements regarding the content of lessons learned.

3.4.1 Making and Implementing Decisions

The results of this study show that actors *in projects* use lessons learned as an input for several of the decision making and implementation phases. They are used as input for the *intelligence* phase (e.g., through monitoring of leading indicators), as input for the *design* phase (by providing ideas and initial solutions, or by evaluating potential solutions), and as input for the *implementation* phase (e.g., by providing an alternative that is actually implemented).

Similarly to the usage in projects, lessons learned are used *on an organizational level* as input for the *intelligence* phase (e.g., for generalizing a problem), as input for the *design* phase (e.g., in MarineOrg's second process focusing on detailed actions), and as input for the *implementation* phase (e.g., in ConstructOrg when the root cause analysis and generalization had already been performed for a lesson learned).

Combining both the usage in projects and in an organizational context, lessons learned may be used as input for the decision making phases outlined in Table 3.2 on the facing page. Using a lesson in the intelligence phase may be followed by its usage in the design or implementation phase. Therefore, a single lesson learned can be used in more than one phase. Furthermore, for using a lesson in the design phase, the users of a lesson learned have to match their situation to the experiences and outcomes in the lesson learned, and realize that the solution in the lesson requires modifications before it

[7]The usage processes can also be characterized through the extent it involves collaboration between various stakeholders in the organization, and whether it is a formal or informal process. Even though some usage processes may be more difficult to realize without collaboration or as an informal process, the study has not found any evidence that these characteristics actually lead to specific requirements regarding the content of lessons learned. Therefore, they have not been included in the discussions.

can be used in their situation. For using a lesson in the implementation phase, the users have to match their situation to the experiences and outcomes in the lesson learned, and realize that the solution in the lesson is acceptable in their own situation.

Table 3.2: Framework explaining the usage of lesson learned from a decision making perspective

Phase	Activity: lessons learned are used	Content: lessons learned provide
Intelligence	for identifying a potential problem	detailed problem description
	for moving from less problem understanding to more problem understanding	initial problem description
Design	for designing a solution	plan on what kind of solution to develop
	for moving from an initial idea to a potential solution	initial idea for solution
	for adapting a potential solution	potential or partial solution
	for analyzing a potential solution	problem description
Implementation	for implementing a solution without modification	final solution

3.4.1.1 Implications for content

Thus, for using a lesson learned in any of these decision making phases, it needs to contain information that can be used for judging the relevance of the lesson learned for the current situation. As outlined in Table 3.2, the requirements regarding the content of a lesson learned vary with the activity for which the lesson is used. The activity determines the required *maturity* of any *problem description* (ranging from initial understanding to a deep analysis) and *solution* (ranging from initial ideas to final solutions). Even though theoretically it is possible to use lessons learned that do not have any solution (i.e., the lesson learned contains only a problem description), the interviews found no clear example where such lessons were actually used.

3.4.2 Using Lessons Learned inside and outside of a Project Context

Second, the literature study and particularly the interviews show that lessons learned are used to evoke changes in two different contexts: projects and organizations. In order to affect a project, lessons learned are stored in a knowledge repository or lessons learned database and retrieved in a project. Their application then helps to prevent or solve similar problems in that project. In contrast, on an organizational level, lessons learned are used to change the support systems (e.g., IT systems, or project resources) available for projects, or to update existing knowledge assets (such as standards & procedures, or training). These changes may affect the whole organization, or part of the organization (e.g., a single department, a region, or a community of practice).

Using lessons learned for changes in an organizational context has several advantages and disadvantages. In FoodOrg and ConstructOrg, using lessons learned for changing knowledge assets resulted in a continuous integration of lessons learned into knowledge assets. *As a result, project members do not have to do this integration during their project* (A1), which may reduce information overload. Furthermore, the temporal distance between collecting a lesson and using a lesson may be smaller on an organizational level. This makes it easier to involve participants from the collecting process in the usage process, thus allowing for personal knowledge sharing to complement the lessons learned. However, this usage mechanism is only applicable if the organization has (or intends to create) knowledge assets that can serve as targets for lessons learned (D1). Changes in an organizational context require more support from management than changes in a project context, and are therefore more difficult to implement in organizations with informal lessons learned processes (Gibson et al., 2007). Furthermore, updating knowledge assets does not ensure that employees actually use the latest version of the knowledge asset (A3).

3.4.2.1 Implications for content

The context in which a lesson learned will be used may have implications for the *framing of a (past) problem* outlined in a lesson learned. For example, one lesson learned collected in RefineryCol addresses issues with a project premise document, which is created before the start of the project. Understanding this problem on an organizational level has led to questioning the way this documented is created. When using this lesson in a project, the project team has to assess whether their project premises show similar issues as those outlined in the lesson. As a consequence, the *potential solutions* for preventing or addressing these issues vary between the organizational and the project level. On an organizational level, the way a project premise document is created can be changed. On a project level, the project team needs to find ways to deal with inadequate or unclear project premise documents, e.g., by questioning the premises and asking the project owner for clarification. Similarly, for a contractor organization such as MarineOrg, tendering processes and asset management can be addressed on an organizational level. On a project level, contracts could be more difficult to change, and solutions might focus on issues that arise as a consequence of a particular contract. Both examples focus on the importance of the temporal boundaries of a project as limitations for potential solutions applied in a project. On the other hand, the project level is more specific than the organizational level: relevant stakeholders, locations, and the task of the project (among other things) are already known. This allows projects to develop solutions that work in their specific context, or that require the agreement of particular stakeholders.

Overall, these examples show that a different problem understanding can lead to different solutions for addressing the problem – the organizational and the project context represent different problem and design spaces. If a lesson learned outlining solutions on an organizational level is only used on a project level, it may actually lead to frustration (C1). In contrast, if a lesson learned outlines problems or solutions on a project level, the interviewees often find it acceptable to *generalize* the problem to the organizational level during the usage process.

3.5 Conclusions

This chapter explored the question when lessons learned are fit for purpose for repeating successes and preventing repeated mistakes in future projects using a literature study and an interview study.

The study shows that the purpose of a lesson learned can be achieved (1) by using that lesson directly within a project, or (2) by evoking changes on an organizational level (with the expectation that these changes in turn influence the projects of the organization). In both cases, the interviews provide evidence that the usage processes can be framed as part of a decision making process covering one or more decision making phases as outlined in Table 3.2 on page 41. In simple cases, lessons learned can be used to raise awareness of (otherwise unknown) problems.

For the organizational level, literature shows that lessons learned are used to change standards and procedures, or training materials. The interviews show that the usage of lessons learned goes beyond these changes by including a wider range of organizational decision making (e.g., for changing tangible assets). For the project environment, literature provides evidence that lessons learned are used reactively after a problem has occurred, whereas the interviews showed that lessons learned are used both proactively and reactively. Overall, the usage processes are characterized by (1) the decision making phases requiring a lesson learned as input, and (2) the context in which the problem or issue is addressed.

This thesis argues that a lesson learned is fit for purpose when its content and quality make it a suitable input for the intended usage processes. Both characteristics have specific implications for the content and quality of a lesson learned (see Box 3.3 for the quality dimensions).

The characterization of the usage processes leads to several implications for LLCPes. First, for lesson learned collection processes to be effective, *organizations need to decide how they want to use lessons learned* (using Table 3.2 on page 41). In particular, they need to decide whether lessons learned need to outline *solutions* to a gap they describe or whether a problem understanding (without solutions) is sufficient. In addition, they need to clarify their expectations regarding the maturity of both problem understanding and any suggested solutions.

Depending on the choices an organization makes, a lesson learned collection process may need to handle the following situation/challenges:

- the participants cannot provide a mature problem understanding, e.g., because key perspectives on the problem are missing
- the participants do not know how to address a (complex or ill-defined) problem (and are expected to develop initial solutions).

Last, considering the impact of using lessons learned on a project and an organizational level on the problem understanding outlined in a lesson learned, a *LLCP needs to consider in which context (project, organizational, or both) a lesson learned is used.*

Box 3.3: Quality criteria for lessons learned

General quality criteria

- Understandability: sufficient context, appropriate visualizations, appropriate level of abstraction, consistent/standardized format
- Level of detail/specificity: needs to match usage context; both too specific and too general may be inadequate
- Quality/maturity of problem description: needs to match usage context
- Maturity & practicability of solutions: needs to match usage context

Quality criteria for usage on an organizational level

- Generalizability
- Focus on the organizational level

Quality criteria for usage on a project level

- Transferability to projects: process knowledge is more likely to be transferable than product knowledge; product knowledge is particularly relevant for similar projects
- Practicability of solutions
- Focus on project context

This chapter has framed the usage of lessons learned from a problem-solving perspective, and demonstrated that several distinct processes are subsumed under the concept 'using a lesson learned'. However, it has not taken into account a potential political dimension of using lessons learned. A case study in the health sector on organizational learning from an adverse event has observed the importance of politics for organizational learning (Tamuz et al., 2011). Future research should explore the politics of using lessons learned on an organizational level and a project level.

Furthermore, the differences in usage processes lead to two opportunities for future research. First, future research on why organizations have problems learning from projects needs to take variations in the usage processes into account. Extant literature does not clarify how an organization uses or intends to use lessons learned. Thus, future research needs to explore how the usage processes are linked to challenges for learning from projects.

Second, the variations with regard to the content of lessons learned lead to the question on how the process for collecting lessons learned can produce lessons that are fit for their intended purpose. The following chapter shows that collecting lessons learned entails its own challenges. Some of these challenges influence the content and quality of lessons learned, and dealing with these challenges might provide a partial answer to this question.

Chapter 4

What Makes Collecting Lessons Learned Challenging?

Lessons learned programs in organizations are not always successful (see, e.g., Newell et al. (2006); Keegan and Turner (2001)). Literature on lessons learned collection offers several explanations for this phenomenon. Factors prevalent in these explanations relate to the influence of the organizational and project environment on the LLCP, the motivation and skills of participants, and characteristics of the ICT support for collecting lessons learned, for example. The term challenge is used to indicate a factor that can make it difficult to collect useful lessons learned.

This chapter explores these challenges, thus answering Research Question **RQ2** on page 12. It uses a literature study as well as interview materials (the interviewees overlap with those presented in Chapter 3 on page 33) to address this question.

Next, the research approach is presented in more detail, followed by the results of the analysis.

4.1 Research Approach

The research approach was based on literature addressing challenges (or concerns) regarding LLCPes, as well as interview materials addressing this topic.

Table 4.2 on page 48 provides an overview over the literature. There are several noteworthy trends regarding the research approaches used in these publications. First, literature encompasses mainly conceptual research and qualitative, non-observational research. Challenges presented in these publications might therefore be influenced by the sampling of interviewees and other research participants. For example, facilitators of LLCPes (see Kasi et al. (2008)) might consider different challenges than project managers (e.g., Newell et al. (2006)). Also, the impact of the challenges on the process outcome has typically not been researched independently (e.g., there are no comparative case studies or quasi-experiments on whether challenges caused by attitudes or memory issues actually influence the quality of the collected lessons learned).

Second, the conceptual research considered in literature has gaps. For example, it does not provide insights into whether group issues (e.g., social loafing, or the influence of minorities on group results, see Nijstad (2009)) or factors influencing counterfactual thinking (see Girotto et al. (1991, 2007); Pighin et al. (2011) for examples) lead to challenges in LLCPes. Even if extant theories are referred to, the analysis is not systematic (e.g., while forgetting is discussed, exposure to and memory of false or misleading information (Loftus, 2005) is not considered).

Third, extant research does not consider the benefits of the factors that are considered challenges. For example, challenges leading to negative emotions (and a dominance of negative lessons learned) might very well have positive effects in that it motivates participants to use the lessons learned on an organizational level, or in their own future projects.

Furthermore, the publications predominantly focus on organizations experiencing difficulties in collecting or using lessons, or on organizations implementing new LLCPes. Thus, literature is limited in that it does not review challenges encountered in more successful efforts to collect lessons learned.

Last, the publications on collecting lessons learned typically do not provide details about the detailed approach to a LLCP, or the instruments supporting it. As a consequence, the literature provides little insight into how challenges vary with various approaches or instruments.

For the interview study, the interviews at ConstructOrg and FoodOrg were analyzed with regard to concerns regarding LLCPes (see Table 4.1 for an overview over the interviewees).

Table 4.1: Interviewees and their organizations

Organization	Status of LL Program	Interviewees[a]	Position	Involvement with LL
		A1	Vice president for knowledge management	Responsible for whole LL program
ConstructOrg	Functioning formal LL processes	A2	Quality assurance director	Organization of LL sessions Has presented a workshop on LL in the construction industry
		A3	Knowledge manager	Collection and analysis of LL in a community of practice
FoodOrg	Functioning formal LL processes	B1	Knowledge management consultant	Involved in designing a global KMS incorporating LL Collects, analyzes, and documents good practices

[a] The interviewees' acronyms are used to present the results from the interviews

The challenges mentioned in literature relate to the concepts and relationships depicted in Figure 1.1 on page 8. Therefore, the following concepts from that model were used as an initial framework for analysis:

- the process output
- the environment

- the participants
- additional properties of the LLCP (particularly the available time and task goals)
- instruments and supporting roles

The motivation to participate and to contribute in LLCPes emerged as a major cluster of challenges in both literature and the interviews. To further understand these motivational factors, a diagnostic framework proposed by Rheinberg (2004); Rheinberg and Vollmeyer (2011) was used.

Table 4.2: Literature on challenges and concerns in LLCPes

Source	Research Method	Basis for Concerns and Challenges	Domain	Location	Aim of Study
Baaz et al. (2010)	Conceptual and action research Unit of analysis: post-mortem evaluation	Personal experiences of authors and quantitative data on the ratio of positive and negative experiences	ICT	not mentioned (action research took place at Ericsson)	Develop a method that allows learning from what went right as well as what went wrong
Busby (1999)	Exploratory, inductive non-participant observation Unit of analysis: project reviews	Literature, semi-structured interviews with participants, analysis of transcripts of 4 project reviews in 3 organizations	capital equipment design	not stated	Describe postproject reviews as a mechanism of organizational learning in the setting of *real* organizations
Cooper et al. (2002)	Conceptual research (for challenges)	Personal experiences of the authors	multiple technical domains (e.g., shipbuilding, ICT, construction)		Present an approach for learning from projects (approach uses a modelling framework)
Disterer (2002)	Conceptual research	Unknown (probably a transfer of barriers to knowledge transfer identified through a previous literature study (see Disterer (2001))	ICT		Combine project management and knowledge management perspective on the transfer of project knowledge and experiences from the project to the organization
Gibson et al. (2007)	Mixed method design using surveys and interviews Unit of analysis: organization	Responses from 68 member organizations of the Construction Industry Institute (CII) for the first survey 38 responses for the second survey 26 interviewees from 10 organizations	mainly construction (CII members)	mainly USA	Analysis of lessons learned programs in the construction industry
Kasi et al. (2008)	Exploratory qualitative research using a Delphi study	Seeds: barriers from literature and one case study Delphi panel: 23 practitioners with experience in performing PMEs	ICT	Scandinavia	Explain why post-mortem evaluations are not conducted in the IT industry

Continued on next page

Table 4.2 – continued from previous page

Source	Research Method	Basis for Concerns and Challenges	Domain	Location	Aim of Study
Keegan and Turner (2001)	Inductive qualitative study Unit of analysis: project processes common to all projects	Semi-structured, open-ended interviews in 19 European organizations from various industries (44 interviewees)	multiple domains (e.g., engineering, construction, ICT)	North and Middle Europe	Studying practices for learning through projects with a focus on learning between projects (not within projects)
Newell et al. (2006)	Exploratory qualitative case studies Unit of analysis: project	Interviews, project documentation, and on-site observations in 13 projects in 6 organizations from various industries	multiple domains (e.g., automotive, construction, health)	UK	Understand the processes used for transferring learnings across projects and barriers towards ICT driven knowledge transfer
Swan et al. (2010)	Exploratory qualitative case studies Unit of analysis: project	Interviews, project documentation, and on-site observations in 13 projects in 6 organizations from various industries None of the organizations had a formal KM strategy	multiple domains (e.g., management consulting, engineering, construction, ICT)	UK	Studying practices for learning in and through projects in varying organizational contexts (variations of matrix organizations)
Tan et al. (2006)	Conceptual and case study research Unit of analysis: organization	18 interviews with senior staff in 6 organizations (construction industry)	construction	not stated	Study requirements for the ”live” capture and reuse of project knowledge as well as the shortcomings of existing practices in meeting these requirements’
Wiewiora and Murphy (2015)	Case study research Unit of analysis: organization	39 interviews mainly with project managers (but also senior management, program managers, ..) in 4 organizations	multiple domains (e.g., engineering, ICT, mining)	not stated	Understand how the process of LL worked (including its problems), and explore possibilities for alternatives
Williams (2003)	Conceptual research (for challenges)	Literature			Explain why lessons are difficult to get from complex projects
Von Zedtwitz (2002)	Conceptual research (for challenges)	Literature (not all challenges could be traced back to the originating literature)	R&D		Reviews the role of post-project reviews as a tool for organizational learning, focusing on the group level

4.2 Process Output

Usage processes for lessons learned rely on the collected lessons learned. Both literature and the interviews identified concerns relating to this type of process output. One area of concerns relates to a lack of *quality* of lessons learned. These concerns have already been reviewed in Chapter 3 on page 33, and are therefore not repeated in this section.

4.2.1 ... in Literature

Literature highlighted two additional concerns. First, the *quantity* of collected lessons learned might be below expectations (Keegan and Turner, 2001). Second, Baaz et al. (2010) found that the set of lessons learned might be biased. More precisely, their case studies in one organization from the ICT industry indicated that the collected lessons learned were *dominated by negative lessons learned*. Conversely, positive lessons learned were underrepresented (Baaz et al. (2010) arbitrarily defined this as less than 40% of the lessons learned collected in one (collaborative) collection process.).

4.2.2 ... and in the Interviews

The interviewees also addressed concerns with the set of collected lessons learned. One concern is the *uniqueness* of lessons learned. In ConstructOrg, the verification of a lesson learned frequently let to the recommendation that the project team should have followed an extant standard, procedures, or otherwise documented work practices (A1, A2, A3). Similarly, in FoodOrg, lessons learned sometimes were duplicates of insights described in another knowledge object in the organization (B1).

Second, interviewees from FoodOrg and ConstructOrg observed a tendency to *underrepresent either positive or negative experiences*. Employees in FoodOrg typically provided positive experiences (B1), while employees in ConstructOrg had a tendency to focus on negative experiences[1].

4.3 The Environment

The environment directly influences all aspects of a LLCP with the exception of the process output (see also Figure 1.1 on page 8). During the analysis, concerns regarding the environment were clustered by their effect on a LLCP. Overall, concerns stemming from the environment may

- prevent a LLCP from being conducted
- influence whether *potential* participants are involved in a LLCP
- influence the availability of *potential* instruments

Influences on actual participants, instruments, and general properties of a LLCP are reviewed in the respective sections on participants, instruments, and general properties.

In the following, this section reviews factors associated with the three areas of concern.

[1] B1 attributed this difference to industry culture.

4.3.1 … in Literature

4.3.1.1 No LLCP

The most extreme influence of the environment on the collection of lessons learned is when a LLCP is not conducted at all (i.e., when the time available for the LLCP is zero). On an organizational level, a *lack of top management support* correlates with informal and unsystematic efforts to collect lessons learned (Gibson et al., 2007), and can prevent any collection of lessons learned in a project (Kasi et al., 2008).

In addition, project managers are reluctant to collect lessons learned under time pressure in their project, prioritizing current business over LLCPes (Wiewiora and Murphy, 2015), even if they consider the collection of lessons learned a valuable task (Kotnour, 2000). In other words, LLCPes may not be conducted because of a *lack of project management support*. Overall, it can be a challenge to *initiate a LLCP* in a non-supportive environment.

4.3.1.2 Involvement of potential participants

The environment can influence potential participants in such a way that they do not participate in a LLCP at all. Literature identified several potential causes for this phenomenon.

First, potential participants may not be *aware of lessons learned programs in their organization*. (Kasi et al., 2008) categorized this challenge as an educational issue: employees need to be trained not just in their discipline but also in organizational problem solving.

Second, for LLCPes that rely on workshops (and similar synchronized group processes), potential participants may not be *invited*. For example, it can be impractical or difficult to include all potential participants (Kasi et al., 2008), resulting in a selection of participants providing their information.

In addition, a conflict between daily business and involvement of a LLCP may also arise on an organizational level due to bad planning. (Kasi et al., 2008) found that if LLCPes were not considered in the project *schedule*, this could result in bad preparation, and fewer people involved in the collection of lessons learned.

Even if potential participants are aware of LLCPes and given the opportunity to participate in a LLCP, they may still be *motivated to spend their time on other activities*. Here, time pressure within projects or the organizational environment, and the accompanying high workload for employees is presented as one of the major challenges employees face when collecting lessons learned (Kasi et al., 2008; Swan et al., 2010; Keegan and Turner, 2001; Disterer, 2002). Employees in projects may work full-time or overtime on a project due to tight deadlines (Keegan and Turner, 2001). Consequently, employees are either not available for organized efforts to collect lessons learned (such as meetings) or, encouraged by hard deadlines, they see lessons learned as being of lower priority[2] (Newell et al., 2006). The time pressure on potential participants can also lead to lessons learned practices being marginalized in practice (Swan et al., 2010).

[2]This phenomenon may be explainable by motivational theory. For example, temporal motivation theory models the motivational influence of approaching deadlines, arguing that a person's preference for a task increases curvilinear when the deadline for that task approaches (Steel and König, 2006).

Therefore they do not get involved in the collection of lessons learned. Thus, employees focus on „getting the job done and going onto the next one and not really learning lessons from where they have gone wrong in the past" (Swan et al., 2010). As (Kasi et al., 2008) put it: employees are „getting lost in current business". As a consequence, they spend little to no time on articulating and codifying knowledge (Swan et al., 2010; Disterer, 2002) or reflective learning practices (Kasi et al., 2008). Thus, high workload can prevent potential participants from getting involved in the collection of lessons learned. It may also reduce the time they are willing to spent on a LLCP.

Tight deadlines and high workload characterize the issue of participation as a conflict between spending time on tasks stemming from the daily business (often driven by deadlines) versus spending time on collecting lessons learned. Organizations have recognized the problems associated with tight deadlines, and interviewees from one organization in Keegan and Turner (2001) study planned to handle this challenge by giving project managers the responsibility for learning within a project, and by evaluating project managers on whether learning objectives within a project are actually met. However, the effect of this intervention was not known at the time of the study.

Another motivational conflict arises when the project members strongly *identify* with a project, and are judged by others on how well the last project performed. In such an environment, project members may set their priorities accordingly – project goals come first, organizational interests come second. Consequently, if lessons learned are considered only as organizational interests, then the motivation for collecting lessons learned may be reduced or not present (Swan et al., 2010).

Overall, these factors consider motivation relative to other activities. Literature also addressed several factors that resulted in an overall *low motivation for participants to collect lessons learned*. (Newell et al., 2006) argued that the temporal relationship between a project and a LLCP may influence motivation. More precisely, a time lag between the completion of the project and a LLCP can make it difficult to motivate employees to participate in the LLCP.

Another cluster of causes focuses on the attitudes[3] and beliefs of the participants. In this context, a belief in the uniqueness of a project or the issues encountered therein can lead to the belief that the collection of lessons learned has only a modest impact on other projects (Kasi et al., 2008; Newell et al., 2006; Von Zedtwitz, 2002; Cooper et al., 2002). Similarly, a potential participant may consider the collection of lessons learned as an exercise in documentation, because resulting lessons learned do not seem to be used (Newell et al., 2006). How the retrieval of lessons learned is perceived can have a negative impact as well. Lessons learned repositories can be hard to handle, and information is difficult to find (Swan et al., 2010). Similarly, actors may have difficulties with locating relevant lessons learned embedded in a report (Tan et al., 2006). Consequently, lessons learned collections are considered skeptically, even when information from other projects is available (Swan et al., 2010). One consequence of these difficulties in retrieving lessons learned is that project members do not seek out these databases or reports themselves (Swan et al., 2010). All of these issues are based

[3] In general, attitudes and beliefs can be shaped through social processes (e.g., the attitudes of coworkers), and through personal experiences (see Section 1.2 on page 7). Literature on attitudes towards lessons learned collection processes typically does not elaborate on how the attitudes are formed, but general KM literature points out the influence of coworkers, and supervisors on user satisfaction (Kulkarni et al., 2007).

on the perception potential participants have regarding the use of lessons learned or lack thereof. These issues can lead to a lack of positive personal experience with lessons learned, and, as a result, participants (including project managers) do not see the value in lessons learned (see also Wiewiora and Murphy (2015)) and consider it unimportant to contribute their own lessons learned.

The time potential participants spend on a LLCP influences the amount of contributions (insights, experiences, and knowledge) shared by participants (Tan et al., 2006), which in turn may be influencing both the quantity and the quality of lessons learned. Consequently, there may be a trade-off between the quantity and quality of collected lessons learned[4] (mitigated by the time spend on the LLCP).

4.3.1.3 Availability of instruments

In addition to concerns relating to a lack of participants, there are also concerns relating to a lack of instruments. Here, an organization may not *provide* standardized procedures and templates (Kasi et al., 2008) or clear guidelines (Wiewiora and Murphy, 2015) resulting in inconsistent formats (and storage locations) (Wiewiora and Murphy, 2015).

Furthermore, a general lack of instruments may be the result of a lack of financial resources. Organizations considering the introduction of a new methodology for LLCPes expect that the new methodology should not create significant additional costs (Tan et al., 2006). However, a lack of resources (including costs) characterizes immature lessons learned programs in the maturity model of the CII (Gibson et al., 2007), and can prevent the collection of lessons learned altogether (Kasi et al., 2008). In general, both specific ICT support for collecting lessons learned, as well as facilitators for lessons learned collected in workshops require financial resources. Thus, a lack of financial resources may result in *limiting* access to facilitators, and difficulties in *providing* ICT support. Tan et al. (2006) found that one of their case companies expected that the costs should be justifiable by the benefits. However, most organizations utilizing a formal lessons learned program just assume that the benefits outweigh the cost, because assessing the benefits or quantifying any return of investment for a lessons learned program is a challenge in itself (Gibson et al., 2007).

4.3.2 … and in the Interviews

4.3.2.1 No LLCP

Overall, for ConstructOrg and FoodOrg *initiating a LLCP* is less of a challenge. One interviewee from ConstructOrg acknowledged that gaining project management support for conducting LLCPes was a continuous effort (A3). ConstructOrg addressed this challenge by making project managers responsible for collecting lessons learned, and utilizing quality audits for controlling project managers and enforcing LLCPes if necessary (A3).

[4] A similar argument exists for the trade-off between the quantity and quality of the lessons learned processes (instead of their outcomes) (Keegan and Turner, 2001).

4.3.2.2 Involvement of potential participants

Similar to literature, the interviews revealed concerns about *getting potential participants involved in a LLCP* (A2, A3). This theme was considered a major challenge in all organizations. The interviewees attributed difficulties in this area to factors that were also found in literature, but in contrast to literature, the interviewees also suggested several approaches for addressing these factors.

First, a lack of involvement was attributed to a *lack of awareness* about lessons learned. Interviewees from ConstructOrg compared two settings: a dedicated lessons learned database (used at ConstructOrg several years before the interviews), and a KMS integrating[5] lessons learned with standards and procedures (used at ConstructOrg at the time of the interviews). The dedicated database had made it difficult to raise awareness about lessons learned among employees (A2). Conversely, ConstructOrg found that the integrated KMS improved awareness and retrieval of lessons learned (A2). FoodOrg had similar experiences with their integrated KMS (B1).

Second, conflicts associated with deadlines and time pressure were acknowledged as a factor influencing the *motivation of potential participants*. Interviewees from ConstructOrg consider„ people actually taking the time to submit a lesson learned" (A2) or getting people to participate in collaborative LLCPes (A3) a difficult challenge, because „when working towards a deadline the deadline is more important" (A2). These deadlines included also last minute deadlines set by a manager (A2). Overall, „encouraging participation in the system is a never-ending battle and probably the most difficult thing" (A2). Similarly, in FoodOrg, employees may be too busy to actually use the knowledge management system (B1).

Unlike organizations described in literature, ConstructOrg had some experience in addressing this challenge. They attempted to reduce the conflict by changing the attitude of supervisors, so that employees got the time to contribute lessons learned, or by using facilitated LLCPes (A2). In addition, they made the participation in collaborative LLCPes mandatory: „Every person, and there is no exception, has to do a lessons learned session" (A3). As a result, not having the time to participate in a LLCP was not accepted as a reason for not delivering lessons learned (A3).

Last, the tendency to defer the collection of lessons learned to the end of a project was a concern in ConstructOrg (A1), because „by that time [the end of the project] many of the people on the project [had] been reassigned to new projects". Such *reassignments* might result in a lack of motivation (the new project is more important) as well as a lack of awareness on when the old project performs a LLCP. To mitigate such negative effects, projects were encouraged to *invite* former project members to a LLCP. In addition, collaborative LLCPes were scheduled after major activities in a project (e.g., after the proposal stage or primary engineering of a project).

4.3.2.3 Availability of instruments

In contrast to concerns regarding a lack of instruments derived from literature, FoodOrg and ConstructOrg provided facilitators and KMS to collect lessons learned. Top man-

[5]The integration was realized through a navigation menu displaying lessons learned next to standards and procedures, and a search engine presenting both standards and procedures and lessons learned in separate categories.

agement at ConstructOrg considered their knowledge management efforts a competitive advantage, and was therefore willing to continually invest into their KMS as well as supporting personnel such as facilitators (A2). At the time of the interviews, FoodOrg extended their KMS and was preparing to deploy it in other parts of their organization (see Section 2.4.1 on page 30). Nevertheless, the knowledge manager also acknowledged that costs could pose an issue at FoodOrg (B1).

4.4 The Participants

The environment influences whether individuals participate in a LLCP (see Section 4.3.1.2 on page 51 and Section 4.3.2.2 on the preceding page for concerns regarding this transition). Making this transition is not the only concern regarding individuals. Both literature and the interviews outlined concerns that only occur when individuals actually participate in a LLCP. During the analysis, these concerns were clustered on how they affect the LLCP, resulting in:

- concerns affecting whether experiences are communicated
- concerns affecting how an experience is analyzed
- concerns affecting both the communication and analysis of an experience (interviews only)

In the following these areas of concerns are presented in more detail.

4.4.1 … in Literature

4.4.1.1 Is an experience communicated?

Two groups of challenges associated with participants address the question whether an experience is communicated or not.

The first group is concerned with a participant's *motivation* (or lack thereof) for sharing an experience. Wiewiora and Murphy (2015) found that participants might discuss lessons learned, but did not document them due to *unclear responsibilities*. Other factors influencing the motivation can be further divided into whether they affect the sharing of positive or negative lessons learned.

Thinking about negative lessons learned can lead to re-experiencing the past, resulting in negative emotions such as frustration or anger[6] (Kasi et al., 2008). Furthermore, participants can be reluctant to share experienced problems due to concerns that this could be interpreted as them having made a mistake (Newell et al., 2006). A reluctance to blame or criticize team members (Busby, 1999; Von Zedtwitz, 2002), or to admit own mistakes (Von Zedtwitz, 2002) can inhibit the articulation of negative lessons learned as well. The open and honest productive culture that would facilitate the articulation and analysis of mistakes in a project team is rarely present in most project-based organizations (Disterer, 2002), indicating a lack of *psychological safety*[7] (Kasi et al., 2008). In

[6] In general, a lack of volition in combination with negative emotions such as anxiety or frustration can result in an action/activity not being performed (Rheinberg, 2004).

[7] See also Buttler and Lukosch (2012) on learning from mistakes.

psychologically safe environments, people believe that if they make or admit a mistake others will not penalize or think less of them for it (Edmondson, 2003). In psychologically unsafe environments, the risk of being seen as negative often stops people from delivering critical assessments of a group or individual's performance, which limits the thoroughness and accuracy of collective reflection (Edmondson, 2002). Consequently, process knowledge about things that went wrong may not be collected, and learning from mistakes remains on an individual level: „the people that have made them [mistakes] will learn from them but the company should learn from them as well" (Newell et al., 2006).

With regard to sharing positive lessons learned, a factor influencing motivation relates to the beliefs of participants on what constitutes a lesson learned. Interviewees in Newell et al. (2006)'s research indicated that project successes (e.g., a plan that worked as expected) might not be regarded as lessons learned, because they have already been resolved. Here, a participant's *conceptualization* of lessons learned excludes positive lessons learned, and therefore leads to the belief that sharing positive experiences is ineffective[8] in achieving the purpose of a LLCP.

The second group of challenges focuses on difficulties with communicating experiences.

In this context, literature discussed several memory issues. In extreme cases, participants might not be able to recall experiences (Tan et al., 2006) resulting in forgotten lessons learned or ones of poor quality (Wiewiora and Murphy, 2015). Von Zedtwitz (2002) argued that participants might have difficulties in recalling experiences, because they repress ambivalent experiences unless these experiences are discussed at a group level. Furthermore, Busby (1999) argued that there is a possibility of distorted memories in hindsight: participants might overestimate what they knew when a decision was made (hindsight bias as forgetting when something was known), or they may reconstruct memories incorrectly (e.g., adding extrapolated memories that did not exist in the original situation). Similarly, managers (and other participants) might have "little awareness of past actions and rationales" (Von Zedtwitz, 2002), for example in the context of project successes (interviewees cited by Newell et al. (2006)) or when reflecting on complex judgments (Busby, 1999). In contrast, „the mistakes are the ones you remember because they cost you money [...]" (interviewee cited by Newell et al. (2006)).

Overall, memory issues and changes of judgment in hindsight may affect the quality and quantity of lessons learned, and may partially explain the dominance of negative lessons learned.

Another concern is based on the *tacit nature of process-related experiences and knowledge* (Von Zedtwitz, 2002; Kasi et al., 2008). The authors assumed that tacit knowledge is difficult to share, which might limit the capability to share process knowledge (thus influencing the quality of lessons learned).

4.4.1.2 Processing communicated experiences

Lessons learned are not a verbatim transcript of shared experiences. Rather, participants process or analyze the experiences and decide what they want to communicate to the next project.

[8] German: Wirksamkeitsdefizit

Participants may have difficulties in *identifying work practices*. More precisely, participants may show a „blindness towards [their] own work practice" (Kasi et al., 2008), and in difficulties to identify strength and weaknesses in processes applied in a project (Kasi et al., 2008). Similarly, (Busby, 1999) found that divergent practices were easier to identify than the correct work practices needed in future projects. As work practices are part of process knowledge, these challenges may influence the quality of lessons learned.

Furthermore, participants may find it difficult to generalize from the specific project context in such a way that more *general, transferable lessons learned are derived* (Busby, 1999; Von Zedtwitz, 2002). This difficulty may be enhanced by difficulties and limitations in understanding the complex settings within a project (Williams, 2003; Von Zedtwitz, 2002), by the situated nature of experiences made in a project (Kasi et al., 2008), or by a tendency to reflect on practices in a single project without referring to past experiences with these practices (Busby, 1999).

Understanding the complex settings in a project entails *establishing cause-effect relationships* in lessons learned (Kasi et al., 2008). Establishing cause-effect relationships is a major challenge when collecting lessons learned, and may lead to difficulties identifying the true causes of project performance (Cooper et al., 2002).

There are several factors that might play in role in this challenge. First, Busby (1999) found that participants had a tendency to use forward reasoning (from a cause to a high-level outcome) instead of diagnostic reasoning (from a high-level outcome to potential causes), leading to the identification of very specific causes instead of systemic causes. In this context, Williams (2003) pointed out the difficulty of identifying lessons learned resulting from feedback loops and dynamic, systemic effects in projects, as initially small effects can be greatly intensified.

Second, (high-level) outcome information has limited informative value[9] (Busby, 1999), and it may be difficult to assess the impact of one practice versus another on the project (Cooper et al., 2002). Nevertheless, participants can rely and overestimate the value of outcome information (Busby, 1999).

Another potential cause for difficulties in identifying causes are time lapses between the actual identification of process improvements and the LLCP (Kasi et al., 2008) (also relating to memory issues), suggesting that an earlier LLCP might be helpful for establishing cause-effect relationships. However, an early LLCP can have an adverse effect on the capability to establish cause-effect-relationships, because an understanding of the (long-term) effects of process improvements is missing (Newell et al., 2006).

Furthermore, with regard to *time management* (at least in workshops), Kasi et al. (2008) found that it might be difficult to balance the efforts between understanding a problem and developing improvements, or there may simply be too little time for analyzing the experiences and data from project.

Last, concerns regarding the processing of communicated experiences also arise on a group level (e.g., in workshop settings). Baaz et al. (2010) found that participants in lessons learned sessions criticize these sessions „as an excuse for whining and grumbling" instead of taking the time for reflective learning resulting in useful lessons learned. This indicates that, in a collaborative setting, it might be a challenge to *keep the group focused* on a productive analysis of experiences.

[9] In extreme cases: a good process may result in a bad outcome, and vice versa.

4.4.2 ... and in the Interviews

4.4.2.1 Is an experience communicated?

Similar to literature, the interviews were also concerned with factors influencing whether an experience is shared. With regard to factors influencing *motivation*, some participants „want to believe that everything is fine" (A1), which makes it difficult to „get people to share what really happens on a project" (A1). Others can be apprehensive of negative repercussions in the organization when sharing their (negative) lessons learned (see also the review of psychological safety in Section 4.4.1.1 on page 55). With regard to sharing positive experiences, some participants might consider knowledge to be power and therefore do not share good practices (B1). Others might not realize that a positive experience could be useful somewhere else (B1). A2 found that the conceptualization of lessons learned typically excludes positive lessons learned (which would make sharing positive experiences ineffective for achieving the perceived goal of a LLCP).

In contrast to literature, the interviews also revealed some factors that are rooted in a participant's *national* ***culture***[10]. „For instance a Dutchman will tell you very quickly if something is wrong or not or how you can do it better in their opinion, but like a Chinese person would think twice to tell that immediately. [...] an American may be scared for their job and won't tell anything." (A3)

These behavioral differences were attributed to how mistakes are regarded in a culture: „in some cultures, eastern cultures, they view submitting a lesson as admitting a fault or finger pointing so they will never do that" (A2).

Another contributing factor has been observed at FoodOrg. Here, lessons learned are collected as explicit feedback on standards and procedures. They receive such feedback from Europe and South America, but considerably less from East Asia, because participants in East Asia „say yes who am I to give feedback on your standards, because they are the law, so they are right. While in Holland they say, of course we give feedback to the standards because we know it better" (B1). Nevertheless, employees in Vietnam deviate from the given standards and procedures, e.g., in order to optimize existing processes: „But when they go outside the standards you will never hear it from them. Because it is not allowed" (B1).

Both organizations try to handle these cultural differences through leadership and organizational culture. For example, ConstructOrg shares lessons learned across national boundaries and thus demonstrates that there are no negative repercussions to share lessons learned (A2). Similarly, FoodOrg addresses this issue by establishing trust and demonstrating that any given feedback is appreciated by the organization (B1). Nevertheless, participants from East Asia are still considerably more reluctant to provide feedback than participants from, e.g., Europe, even though the system has been in place for years (B1).

Last, in contrast to the organization described by Keegan and Turner (2001), Con-

[10] Some differences between cultures are well documented. Hofstede et al. (2010, p. 109) asserts, for example, that persons in collectivist versus individualist societies react differently to infringement of social norms. In individualist societies, a person will often feel guilty, independent of whether an infringement is known by others. In a collectivist society a person will often feel shame, but only if the infringement is known by others. While these differences may explain some of the variations described in this section, further research is needed to discern how cultural dimensions influence the collection of positive and negative lessons learned.

structOrg had actually time to assess the effectiveness of making the collection of lessons learned mandatory, and asking employees to collect lessons learned for projects they had already left. As project managers complied with the requirement to collect lessons learned, it turned out that the real challenge was somewhere else:

> „I think just right now getting the projects to really apply this [...] debrief, I think, is a challenge. Often we can put in requirements that projects have to follow and they will follow those processes to check the box in effect if they did the process. *They don't always apply the processes from a strong leadership perspective of understanding why the process is there, understanding that you know it is not just about their one project, it is about assisting future projects*." (A1, emphasis added)

Therefore, making the collection of lessons learned mandatory for a project can ensure compliance with the regulations, but it still remains a challenge to *build commitment and motivation of participants and project managers towards collecting lessons learned that are fit for use in future projects.*

4.4.2.2 Processing communicated experiences

For both FoodOrg and ConstructOrg, several concerns related to processing and analyzing experiences. First, *building commitment and motivation* of participants and project managers towards collecting high quality lessons learned (see Section 4.4.2.1 on the preceding page) affects the analysis of communicated experiences as well.

The second concerns relates to *establishing group focus on the analysis of the experiences*. The interviewees observed that participants would complain or blame others (A2, A3) resulting in lesson learned where participants just stated that something went wrong, instead of evaluating what they wanted to pass on to other projects (A2). In other words, participants might find it difficult to *identify a lesson learned*, and thus need help „to peel the onion and [to] get them to a point where they say, oh yes, well actually the lesson was this." (A2). In this context, they might also have difficulties in separating relevant and irrelevant aspects underlying a single lesson learned (A3), in separating facts from opinions (A3), and in *identifying causes and effects* (e.g., through a root-cause analysis) (A1).

On the other hand, writing down a lesson learned (after the processing of experiences) was not considered a major concern. As one interviewee remarked: „putting it into the right words is not so difficult" (A3).

In contrast, *filtering of lessons learned* might be a challenge. More precisely, participants might communicate experiences based on not following existing standards and procedures (A2, B1), concluding that they should have done what is described in those procedures without being aware that these procedures already exist. In other words, they might be „reinventing the wheel" (A3).

Last, A3 addressed the *interaction with the client* during the analysis of experiences as a potential reason for concern. Here, the question was whether to communicate to a client that the causes for a negative lesson learned were client issue. On the one hand, the client should not perceive the lesson learned as blaming, on the other hand it might improve the way client and contractor are working together.

4.5 Additional Properties of the LLCP

Following the general model depicted in Figure 1.1 on page 8, the process output may also be influenced by some of the additional properties of a LLCP. Apart from the number of participants (see Section 4.3 on page 50), there were two major concerns about the additional properties of a LLCP.

First, as outlined in Section 4.3 on page 50 and Section 4.4.1.2 on page 56, time pressure and tight deadlines are environmental factors that may influence the time available for a LLCP (and therefore also the actual duration of a LLCP).

Second, literature found that a LLCP may have *unclear or conflicting task goals*. These purposes are typically influenced by the environment of a LLCP. For example, if lessons learned are collected during project reviews (Newell et al., 2006; Von Zedtwitz, 2002) or postmortem evaluations (Kasi et al., 2008), the task goals of the overall process mix performance evaluations of projects with the intent to collect lessons learned. These conflicting task goals can inhibit the collection of lessons learned (Kasi et al., 2008) and create a focus on product knowledge about the project (fostered by the desire to show that a project is on track) (Newell et al., 2006). It is noteworthy that such conflicting task goals were not a major concern in the interviews, probably because FoodOrg and ConstructOrg were using dedicated LLCPes (see Section 2.4 on page 29). Processes with mixed task goals (FoodOrg collected lessons learned during audits) were used to elicit positive lessons learned (see also Section 4.4.2.1 on page 58 for challenges in communicating positive experiences at FoodOrg) (B1), so that the task goals did not result in a conflict.

4.6 Instruments as Barriers

The environment influences the availability of instruments during a LLCP (see Section 4.3.1.3 on page 53 and Section 4.3.2.3 on page 54). Their use may be advantageous, because instruments can guide the behavior of participants during a LLCP and they may connect a LLCP with subsequent process steps (see also Figure 1.1 on page 8). However, issues with instruments may also make it challenging to collect lessons learned.

4.6.1 … in Literature

Literature identified two concerns with how instruments influence the behavior of participants.

First, ICT support may *limit the topics* that participants can address in lessons learned. In two reported cases, ICT support focused on costing and performance of suppliers, but did not allow the documentation of lessons learned related to other topics (Tan et al. (2004), as cited by Tan et al. (2006)). Second, Newell et al. (2006) found that existing systems might focus on product knowledge, and were *not appropriate for documenting process knowledge*.

4.6.2 … in the Interviews

The interviewees were concerned with the guidance provided by standards and procedures. Standards and procedures were used to ensure that all the necessary steps for creating a lesson learned were done, and thus to strife for an effective LLCP (A3). On the downside, procedures may reduce *usability* of a LLCP if it is overloaded with details (A3).

4.7 Discussion and Conclusions

This chapter combined a literature study with several interviews in order to review challenges associated with LLCPes. While the literature provided a broad overview of challenges encountered in a variety of domains, the interviews ensured that the perspectives of large multi-national organizations successful in collecting lessons learned were included. ConstructOrg also ensured that there is was an overlap with the domain of the LLCPes presented in the following chapters.

In general, literature and the interviewees addressed similar challenges related to all areas of the basic model. In the following, these challenges are summarized, and major differences between literature and the interviews are highlighted.

First, concerns regarding the **process output** focus on aspects of the collected lessons learned or the set of collected lessons learned:

Out1 the quality of a lesson learned

Out2 the quantity of lessons learned

Out3 the percentage of unique lessons learned

Out4 the ratio of positive to negative lessons learned

There may be a trade-off between **Out1** and **Out2**. Other potential process outputs such as consensus among participants or commitment of participants towards the results were not found in literature or the interviews[11]. @future{investigate process outcomes other than the collected LL}

Regarding the ratio of positive to negative lessons learned (**Out4**), the cases in literature and in the interviews provided contradictory results: cases in the ICT industry and one case in the construction industry indicate a dominance of negative lessons learned, while a case in the food industry indicates the dominance of positive lessons learned. Furthermore, the percentage of unique lessons (**Out3**) learned was not a concern in literature.

The four concerns regarding process output are the result of a complex interplay between the environment, the participants, the instruments (and individuals in supporting roles), and additional properties of a LLCP.

The **environment** influences (a) whether a LLCP is conducted, (b) the number of participants, and (c) the availability of instruments and mechanisms. In turn, these three

[11] These process outputs are studied as output variables in small group research (Fjermestad and Hiltz, 1999).

outcomes indirectly influence the quantity (**Out2**) and quality (**Out1**) of the collected lessons learned. Overall, there are five major concerns leading to the three outcomes (a) to (c):

Env1 *Intention to collect lessons learned on a project level*: If the organization or project management do not support LLCPes, they may not be initiated at all. As a result, lessons learned may not be collected for a project.

Env2 *Awareness about lessons learned efforts*: A precondition for individuals to participate in a collection effort is that they know about lessons learned, particularly for collecting lessons learned through a KMS.

Env3 *Ensuring participation of potential participants* in the LLCP: Assuming individuals are aware of lessons learned efforts and have the choice to participate, they may still choose to spend their time on other activities. Potential participants may have a low motivation to collect lessons learned, e.g., because they believe that lessons learned lack usefulness. Alternatively, other work-related activities may be more important or urgent (e.g., because of tight deadlines, or because project members have already moved on to the next project). Scheduling conflicts for workshop-based LLCPes also fall under this concern.

Env4 *Dealing with large projects* (when setting up a LLCP): For large project teams collecting lessons learned via workshops, the groups may be too large to for a single workshop, resulting in some project members being excluded from the workshop.

Env5 *Providing and limiting instruments*: If the organizations strives to limit costs of lessons learned programs, a LLCP may lack instruments[12] (including access to individuals in supporting roles, e.g., facilitators).

Even though challenges related to all five concerns were mentioned both in literature and in the interviews, the interviews suggested that ConstructOrg and FoodOrg had found ways to handle the challenges associated with **Env1**, **Env2**, and **Env5** .

Quality (**Out1**) and quantity (**Out2**) are also indirectly influenced by the goal of a LLCP, and the time available for the LLCP (which were introduced as **additional properties** of the basic model):

Att1 *Setting the task goal of a LLCP*: Mixing LLCPes with performance evaluations of projects leads to unclear or conflicting task goals, which may impact the performance of the LLCP, and particularly the quality of the lessons learned (**Out1**).

Att2 *Available time*: Due to tight deadlines and time pressure in the environment (not necessarily in the project collecting lessons learned), the available time for a LLCP may be limited.

[12] In contrast, organizations introducing a lessons learned program may need to design or obtain effective instruments and facilitators.

Challenges in the environment influence whether individuals are part of a LLCP. However, even if individuals participate in a LLCP, having (more) **participants** does not automatically lead to more or better lessons learned. Literature and the interviews indicate that participants may not communicate a particular experience, or may have difficulties in analyzing the experiences, leading to issues with the process output.

The non-*communication of an experience* (or part thereof) is attributed to three main factors:

Part1 *Memory issues*: Participants may not encode experiences made during a project, or they may have difficulties to access some of their memories, e.g., because of a time gap between the LLCP and the actual events. Also, memories might be distorted (e.g., containing false memories or suffering from hindsight bias).

Part2 *Tacit knowledge*: Part of the experiences may be difficult to explicate because of their tacit nature.

Part3 *Motivation* to share an experience (see below).

Part1 and **Part2** are theoretical concerns mentioned in literature, but not in the interviews[13]. They may influence the quality of lessons learned (**Out1**). Memory issues may also affect the quantity of lessons learned (**Out2**), and lead to a dominance of negative lessons learned (**Out4**).

In contrast, motivational concerns were discussed in literature as well as the interviews. Motivational factors are particularly relevant for the ratio of positive and negative lessons learned (**Out4**). Sharing negative experiences is associated with anticipated negative consequences in the organization, as well as expected immediate[14] negative consequences such as negative emotions, negative reactions in a group setting and challenged beliefs about the outcomes of the project. The interviews also indicated that values rooted in national culture might influence the motivation to share negative experiences. Similarly, sharing positive experiences is associated with expected negative long-term consequences (loss of power), as well as a perceived lack of effectiveness in attaining the goal of the LLCP (attributed to personal conceptualizations of lessons learned that exclude positive experience and lead to the expectation that successes are not a basis for lesson learned).

Regarding the *processing of experiences*, literature and the interviews are concerned with several challenges:

Part4 *Establishing (and maintaining) a focus on the analysis of experiences*: Participants may just complain or blame each other, instead of evaluating the experiences, and creating lessons learned.

[13] So far, there is little evidence if and how **Part1** and **Part2** negatively influence the collected lessons learned (e.g., there are no studies investigating how the quality of lessons learned depends on the temporal distance between an originating event and a LLCP).

[14] The distinction between immediate consequences of behavior and more temporally distant outcomes resulting from these immediate consequences can be found in psychological models of motivation (see e.g., the distinction between action (or performance) and outcomes made in Vroom (1964, p.19) and the distinction between 'Handlungsergebnis' and 'Handlungsfolgen' in the Rubikon model (Rheinberg and Vollmeyer, 2011)).

Part5 *Identify work practices:* Participants may have difficulties to separate relevant from irrelevant aspects of an experience, to identify correct work practices, and to identify strength and weaknesses of a work practice.

Part6 *Establishing cause-effect relationships*: Difficulties may arise due to complex project settings, a tendency to use forward reasoning instead of diagnostic reasoning, systemic effects in projects, and an overestimation of the value of outcome information. The temporal environment of a LLCP may also contribute to difficulties in this area. Conversely, the cause-effect relationships may foster the understanding of problems underlying a lesson learned.

Part7 *Creating general, transferable lessons learned:* Challenges in understanding the events and situations in a project, and a tendency to focus on a single project may make it more difficult to create transferable lessons learned or generalize from experiences. **Part5** and **Part6** may also be tasks that participants could undertake in order to create more general or transferable lessons learned.

Part8 *Filtering out experiences that were not lessons learned*: As a consequence of a lack of filtering, the process output may contain items that are not unique (e.g., because they are already documented in an organizational procedure) or that are not even lessons learned, thus influencing **Out3**.

Part9 *Interaction with the client*: For a contractor, it may be challenging to communicate to a client that the causes for a negative lessons learned were a client issue.

Surprisingly, **Part9** is a practical challenge, which has not been addressed in literature. It indicates, that there may be tensions between the various stakeholders present during a LLCP.

Last, the interviewees provided one concern with the potential to influence both the sharing and the processing of experiences:

Part10 *Motivation of individuals to produce high quality process output*: If the collection of lessons learned is mandatory, participants may have little motivation to produce a high quantity (**Out2**) or quality lessons learned (**Out1**) as long as the process output meets criteria set by the organization (tick-in-the-box attitude).

Instruments and individuals in supporting roles may help to address the challenges and concerns outlined in this summary. However, they may also be the cause for additional concerns:

Instr1 *Limitations of topics*: ICT systems may limit the choice of topics that can be addressed in lessons learned.

Instr2 *Appropriateness for documenting process knowledge*: ICT systems may focus on product knowledge instead of process knowledge.

Instr3 *Usability of procedures for collecting lessons learned*: Procedures with too many details may be difficult to use.

Part II

Collecting Lessons Learned

Chapter 5

An Extended Model of LLCPes

The previous chapters have explored some of the challenges and quality criteria that are relevant for collecting lessons learned. The following chapters focus on researching potential solutions. In particular, the following case chapters explore Research Question **RQ3** on page 12

How do instruments shape the resulting lessons learned?

To help answer this question, this chapter extends the theoretical foundations outlined in the basic model.

The basic model has three limitations, which need to be addressed in order to explore how particular instruments influence a LLCP:

1. it does not explicitly address the temporal dimension of a LLCP. In other words, the model ignores that the LLCP is a process
2. the notion of instrument used in the initial model is very broad, and does not conceptualize when and how instruments are used during the process, and together with each other, in order to support participants collecting lessons learned
3. the model does not take into account particularities of different approaches used to collect lessons learned

To address the first limitation, Section 5.1 on the following page draws upon information systems literature on processes. To address the second and third limitation, an iterative approach was used. First, literature was used to identify important instruments (including facilitated workshops, and lessons learned repositories) used in LLCPes. Then, these instruments were aligned with instruments expected to be used in the cases, and the notion of instruments was generalized based on literature on the design and structure of these instruments. The purpose of this refining step was to create a model that is specific enough to gather detailed information about the instruments, but general enough to avoid overlooking how instruments were used for collecting lessons learned. The results of the generalization are presented in Section 5.2 on page 69, while Section 5.3 on page 71 presents particularities of the two main approaches expected to be used in the cases.

All in all, the extended model creates a foundation for understanding how instruments may work together to shape participant behavior in LLCPes.

5.1 About Processes

The temporal dimension of a LLCP relates to it being (part of) a process. The Object Management Group (2011) posits that a process is „a sequence or flow of activities in an organization”, with each activity requiring time to be performed. Alter (2013) points out that processes in a working environment can also be semi-structured (e.g., because decisions on what to do next are based on spontaneous human decisions). Semi-structured processes (or parts thereof) can be described as a set of related activities. In both cases, an **activity** can be defined as a component of a process that deals with *what is done* in order to meet the goal of the process (adapted[1] from (Briggs et al., 2014)). In contrast to the definition of an activity, an **abstract activity** describes an idealized notion of an activity (based on Alter (2013)), which can be considered a prescription of *what should be done*.

It follows that a LLCP consists of at least one discernible activity describing what has to be done to get from no lesson learned to one or more (drafts of) lessons learned.

Each activity has a **purpose**, may require an **input**, and can result in tangible or intangible **outputs**. In turn, an output can serve as input for other activities. An example for a tangible output (or input) is a written experience. Intangible outputs (or inputs) relate to changes in participants: during an activity, affect may change, or participants may become more aware about the importance of team building for the success of a project, for example. The output of an activity may be directly related to the collected lessons learned (see also Box 5.1 on the next page), or may be an intermediary output supporting the process itself (e.g., when informing participants about the agenda of a workshop, or when an activity results in adaptations of an instrument).

An activity may be performed by one or more persons in **roles**. This thesis generally distinguishes between people in **supporting roles** and people in a **participant role** [2](see Box 5.2 on page 73 and Section 5.3.2 on page 74 for the role models used in this thesis).

Activities can be *compounds* (Object Management Group, 2011), i.e., they consist of several sub-activities that, together, lead to a meaningful output. A process is such a compound activity, a **phase** is another one. A phase is a meaningful set of activities in a process which are performed in the same time frame (see Section 5.2 on the facing page for an example of a phase).

Overall, activities as parts of a process and the process as a whole share some similarities: both activities and the process have an environment, an output, participants, some additional attributes, and involve supporting roles and instruments. These similarities raises the question about the relationships between components of the basic model (as a model of the process), and their counterparts in activities. Box 5.1 on the next page summarizes these relationships.

The terms process, phase, and activity are used in the following chapters to refer

[1]There are two changes: first, activities are not necessarily performed by people, but may also be automated; second, the term activity refers to what is actually happening, not to what has to be done. The first change allows a comparison of processes, even if in one process a facilitator performs an activity while in another process the activity is automated. The second change expresses the starting point of the cases in collecting data about actual LLCPes.

[2]A LLCP requires participants to contribute to the lessons learned. Therefore, there is at least one discernible activity involving participants.

to different levels of granularity, with an activity usually referring to the lowest level. The purpose, roles, input, and output of the activity are described using lessons learned theory/vocabulary.

Box 5.1: Basic model and activities

How the components of the basic model (i.e., the environment, participants, process output, instruments, and additional properties of a LLCP) relate to the components relevant for an activity (i.e., the environment, participants, output, instruments, and attributes of an activity)

Environment The environment of each activity *includes* the (changing) environment of the LLCP (activities preceding or succeeding an activity are also part of its environment). Participants performing an activity may be influenced by and themselves influence the environment of the LLCP.

Participants The participants in an activity are a *subset* of participants in the LLCP. Inversely, the union of participants across all activities yields the participants of the LLCP. Personal and professional factors may change between and during activities.

Process Output The output of an activity may be a contribution to the process output, and particularly to the collected lessons learned (e.g., by contributing part of a lesson, or by contributing a preliminary draft). However, not every activity contributes directly to the process output

Instruments The instruments used for an activity are a *selection* of the instruments used in the LLCP. Any adaptation of instruments happens during an activity.

Additional Properties (available time & purpose) The duration of the activities should *add up* to less than or equal to the duration for the LLCP, if activities do not run in parallel. The purpose of an activity may be a *sub-goal* of the LLCP. Activities may also have further additional properties (e.g., when considering ways to handle collaborative activities, see also Box 5.3 on page 74) that do not relate directly to the additional properties considered in the basic model.

5.2 Instruments

Section 1.2.4 on page 10 defines an instrument as a means to support an aim related to the collection of lessons learned. This section shows that there is actually a wide variety of instruments supporting a LLCP.

Abstract activities are one type of instrument, because they can be used as a plan for what to do in order to transform an input into an output. Therefore, an abstract[3] LLCP is an instrument as well.

An activity can be supported by (hardware or software) ***tool***s. Examples for tools include a GSS that is used during a brainstorming activity (see Briggs and de Vreede (2009)), a web-based system for collecting lessons learned (see, e.g., Weber et al. (2001)), or a screen to display slides for a presentation.

Furthermore, activities fulfill their purpose utilizing techniques. A **technique** is a prescription of *how* the input of an activity is transformed into its output. For non-automated activities, they structure (among other things[4]) who interacts or communicates with whom, how tools are used, who uses what information, and how information and contributions are gathered from participants. To fulfill their purpose, they may require

[3]When considering the transferability of LLCPes across cases, we are always referring to those abstract processes.

[4]They may be designed to influence group norms, thought processes, emotions, interaction settings, etc..

certain tools or interaction settings. For example, LeafHopper (Briggs and de Vreede, 2009) is a collaborative technique structuring which contributions from other group members a participant may use as inspiration for his own ideas. To fulfill its purpose, a LeafHopper requires dynamic sub-grouping.

The techniques observed in the cases were based on group procedures (i.e., „methods, strategies, and tactics a group uses to execute its work" (Briggs et al., 2014)), techniques for analyzing causal relationships[5], and techniques found in qualitative research (particularly structured and semi-structured questioning; see, e.g., Bryman and Bell (2007)).

Techniques can be general prescriptions (i.e., they are not particular to LLCPes). For example, the LeafHopper technique may be used in a risk assessment process (van Grinsven, 2007), but can also be found in a collaborative document review (Harder et al., 2005). Similarly, structured questioning is often used to guide the collection of personal information on a web site (van Duyne et al., 2007, p. 600ff).

Techniques may need to be complemented with a ***configuration*** in order to create an output that is relevant for LLCPes. For example, LeafHopper may use a prompt to indicate what the generated ideas should be about. For a semi-structured interview such a configuration is the actual interview guide or set of questions. In the context of LLCPes, Plum (2006) proposed guiding questions (German: „Leitfragenstruktur") as a key instrument for improving the usability of lessons learned. Overall, these configurations are a means to influence what participants contribute during the LLCP.

Techniques may be modified[6] in an attempt to improve the quality of an activity's process output. For group procedures (guided by a facilitator), the aspect of quality improvement has been proposed in Kolfschoten et al. (2011). Based on Kolfschoten et al. (2011) distinguishes between (a) **deficiency prevention**, and (b) **deficiency discovery and (optionally) fixing**. Deficiency prevention focuses on guiding or guarding the quality of contributions. Examples for deficiency prevention include the use of input templates, as well as using tools to display instructions during an activity (as opposed to orally giving an instruction once). Deficiency discovery and fixing focuses on reactively dealing with deficiencies. Deficiency fixing is always a reaction to the discovery of a deficiency. Monitoring the input of the group members for a quality criterion, pointing out discrepancies to the participants, and instructing participants to fix a deficiency is an example for deficiency discovery and fixing.

Modifications of techniques with the purpose to improve quality are not unique to group procedures, but can also be found for other types of techniques. For example, structured questioning via an input template may mark certain questions as mandatory in order to prevent lack of key information. If the form is part of a web site, the software may also discover missing information, and display an error message, and instruct the user to add the missing information (van Duyne et al., 2007, p. 607). Similarly, during a semi-structured interview, the interviewer may use follow-up questions to obtain more elaborate or complete answers (Bryman and Bell, 2007, p.486).

Abstracted activities, tools, techniques, their configurations, and modifications for quality improvement are types of instruments that may be used during a LLCP. They

[5]In contrast to literature, the cases did not employ simulation models (see e.g., Cooper et al. (2002) for an example)

[6]The concept of a modification is primarily used to allow for a better comparability of techniques, and to avoid a combinatorial explosion due to small modifications.

form an assembly that, together, influences how participants behave during a LLCP.

5.3 Particularities of Different Approaches

Guided collaborative processes have several characteristics that may distinguish them from document-based approaches to collect lessons learned. These characteristics relate to the phases of the LLCP, the role model used to describe such processes, and if and how participants can interact.

5.3.1 Characteristics of (Guided) Collaborative Processes

This section outlines several characteristics of guided collaborative processes by combining insights from literature on facilitated meetings, research methods, and the design of collaborative processes for collecting lessons learned[7].

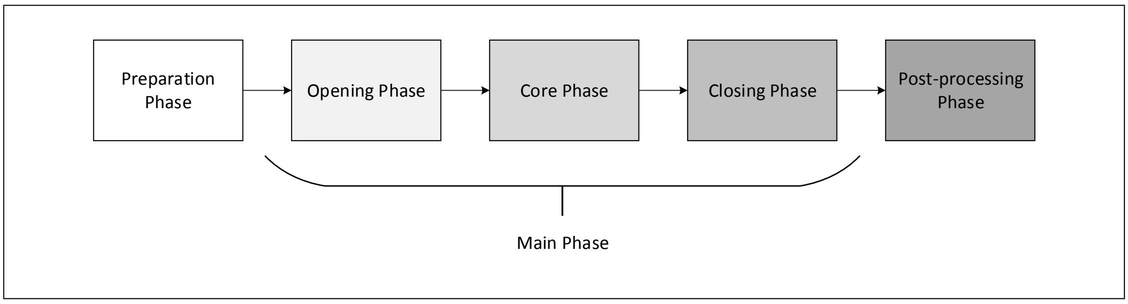

Figure 5.1: Phases of a facilitated collaborative process. Gray scales are used to differentiate between phases.

Phases. First, as shown in Figure 5.1, the temporal dimension of facilitated collaborative processes can be divided into at least three phases: a preparation phase, a main phase, and a post-processing phase (based on Bostrom and Anson (1992)). These phases are particularly useful for categorizing activities.

The preparation phase focuses on designing and organizing the main phase. Table 5.1 on the next page provides an overview of activities that may be part of the preparation phase.

During the main phase the participants perform activities in order to create the outcomes of the LLCP. Bostrom and Anson (1992) point out that the main phase usually starts with an opening phase, and ends with a closing phase (also called wrap-up). The main collaborative activities are performed in a core phase (which Bostrom labeled „during"). During the opening phase, expected outcomes are clarified, and rules (e.g., group norms) are presented. Activities relating to the core phase mentioned in literature vary considerably, and include analyzing lessons learned and formulating suggestions (as a single activity) (Baaz et al., 2010), the creation of causal diagrams (Williams, 2004), or creating action points (Koners, 2005). Activities relating to the closing phase include summarizing results from the core phase, and clarifying actions that need to be performed after the main phase (who will do/has agreed to do what by when) (Bostrom and Anson, 1992).

[7]Although the cited literature focused on interactions supported through GSS, this thesis assumes that the same concepts are relevant for facilitated LLCPes that do not utilize GSS.

Table 5.1: Deriving preparation activities and their outcomes. The activities and their outcomes are based on literature about meeting supported by GSS (Bostrom and Anson, 1992), and a review of guidelines for PPRs provided by Koners (2005)

Preparation activity	Activity Output	Basis in GSS Literature (Bostrom and Anson, 1992)	Basis in literature on PPRs Koners (2005)
Define goal	Task goal and purpose of the collection process	Define business issue (purpose), and map it to meeting outcomes (task goals)	Objective of PPRs
Design or adapt process	Defined sequence of abstracted activities (with their task goals) Agenda	Develop the agenda as a sequence of abstract information processing activities	Use of guidelines for PPRs Duration of PPRs (as part of the planning)
Select & inform participants	Agreement of people to participate in the collection process Participants are informed about times and places Participants know what they need to prepare	Select & inform participants, establish roles	PPR participants
Select facilitator	Agreement of facilitator to facilitate the collection process	Facilitator selection is implied, as the authors only consider meetings with facilitators	Moderation of PPRs
Select ground rules	List of ground rules	Establish ground rules	(not mentioned)
Select & organize tools	Physical and software tools are available during workshop	The use of a GSS and accompanying hardware and software is implied, as the authors discuss the preparation of electronic meeting designs.	(not mentioned)
Organize location	Rooms, workplaces, and suchlike available for collection process	(may not be needed for GSS)	Location of PPRs
Select & prepare (other) instruments	Selected techniques & configured instruments	Match GSS tools (e.g., voting) or manual techniques to agenda activities, and configure them (e.g., a scale for voting).	Discussion methods

The post-processing phase may contain activities that aim to handle any products from the main phase (e.g., disseminating results and monitoring the implementation of actions) (Bostrom and Anson, 1992). Following the case boundaries (see Section 1.4.2.1 on page 16), this thesis only includes activities that lead to the creation of written lessons learned. Activities for monitoring actions associated with lessons learned are not considered part of the LLCP, for example.

Roles. The second characteristic relates to the roles that perform in the activities (see Box 5.2 on the next page for the roles relevant for the cases). The list of roles in

Box 5.2 is not complete (e.g., there may be additional supporting roles related to research techniques), and not every role is relevant for every guided collaborative LLCP. While all approaches to collecting lessons learned require people who contribute their experiences, facilitators are particular to facilitated collaborative processes. The presence of a writer as a supporting role indicates a process where the participants do not do all of the writing themselves.

Box 5.2: Roles in guided LLCPes

Participants

Contributor contributes to the lessons learned, e.g., by communicating or analyzing experiences. Literature suggests that contributors will be key members of the project team (Koners, 2005; Baaz et al., 2010).

Session owner initiates the LLCP. May be involved in preparation activities (e.g., formulating goals, and the design of the process (Bostrom and Anson, 1992)).

Moderator leads a group of participants with the intent to collect lessons learned. The moderator him-or herself may contribute to the lessons learned, and may have decision-making authority (see also facilitator; the role of the moderator is based on observations that project members may lead the LLCP, see, e.g., Koners (2005)).

Supporting Roles

Facilitator performs activities in all phases of the process, with the intent to help a *group* of participants to collect lessons learned (see, e.g., Clawson and Bostrom (1993) for a more detailed discussion of the facilitation role in the context of GSS). In the context of this thesis, a facilitator is not a contributor, but remains in the role of a facilitator due to a neutral or external position in relation to the project. [a] (see also moderator).

Writer analyzes and summarizes contributions of participants in order to create drafts of lessons learned (Liebowitz (2008) proposed a similar role)

Interviewer performs activities for eliciting lessons learned from a *single* participant (at a time) using interviewing techniques (see, e.g., Bryman and Bell (2007) for activities performed by an interviewer, and Birk et al. (2002) for an example of semi-structured interviews used to collect data for lessons learned).

[a] In contrast, Bostrom and Anson (1992) considers group members to be secondary facilitators.

Interaction Setting. Last, collaborative activities take place in an interaction setting that influences who can interact with whom in what way, and may limit what participants can observe about each other. The interaction setting may be created or influenced during preceding activities (e.g., preparation activities often influence the interaction settings in the main phase).There are several aspects of the interaction setting discussed in literature (see Box 5.3 on the next page).

If lessons learned are collected at the same time in the same place, characteristics of the location can also influence the interaction. In this context, Koners (2005) found that both formal and informal social settings were used in R&D projects. Furthermore, for co-located, synchronous activities, a meeting room design may influence the interaction between participants (see Justice and Jamieson (2006) for various meeting room designs, and their applications).

Box 5.3: Interaction setting in LLCPes

Interaction in general

Expression mode: among others, participants can make contributions orally, in writing, verbally (a mixture of orally and in writing), or by drawing something (based on Nagasundaram and Bostrom (1994))

Anonymity: The contributions of participants may be *anonymous*, i.e., group members cannot identify the author of a contribution through direct observation or through identifiers for that author (see, e.g., Valacich et al. (1992); Aljafari and de Vreede (2010); Nijstad (2009) for content[a] anonymity and anonymity in computer mediated communication). Alternatively, participants may be able to identify who contributed what (no anonymity).

Interaction among participants (yes/no): participants may interact with each other or not (Nagasundaram and Bostrom, 1994)

Interaction in groups

Sub-grouping: if participants interact with each other, they may work in sub-groups (see Baaz et al. (2010) for an example) or interact in a single group.

Simultaneity: within a (sub-)group, participants can make contributions simultaneously (e.g., each participant typing an idea at the same when using a GSS, see, e.g., Nijstad (2009)), use turn taking (one participant talks at a time; speaker changes are locally organized) or follow a predefined (possibly role-based) formula organizing who can contribute next

Relative location: participants can be co-located or distributed across multiple locations (Nijstad, 2009; Nagasundaram and Bostrom, 1994, p.220). A mixture of co-location and distribution may also be possible.

Synchronicity: participants may interact at the same time (e.g., in a video conference) or asynchronously (Nijstad, 2009, p.220)

[a] Process anonymity (Valacich et al., 1992) refers to the participants' capability to determine whether other group members are participating. This type of anonymity is not considered in this thesis.

5.3.2 Characteristics of KMS /LL Repositories

Roles. The role model for lessons learned collected through a knowledge management repository can be kept very simple. This thesis distinguishes between ***authors*** and ***supporters***. Authors are participants who contribute to a lesson learned, and create drafts of lessons learned. Supporters are non-participants who provide assistance on technical matters, and help participants to understand the lessons learned processes.

Interaction Setting. In principle, contributions to a KMS can be made by a single author, or by a group of authors. Therefore, the range of interaction settings outlined in Box 5.3 is relevant for such approaches as well. For the collection of lessons learned through a KMS, this overview needs to be complemented with ***Collaborative process (yes/no)*** to indicate whether lessons learned (in a performed or abstracted processes) are collected by a group or a single author.

5.4 Evaluating the Success of LLCPes

Collecting lessons learned is rarely a goal in itself – lessons learned are collected to improve the performance of future projects. The actual use of lessons learned is therefore

Table 5.2: Success criteria for LLCPes. The success criteria are based on literature about success in collaboration systems, and KMS (considered from an information systems perspective).

Concept	Definition
Knowledge or Information Quality of LL	Quality of the collected or stored LL (can be divided into content quality and context and linkage quality) (based on Wu and Wang (2006))
Satisfaction with the Outcome (of the Process or a Phase of the Process)	The sum of one's feelings of pleasure or displasure regarding the outcome of the process (based on Duivenvoorde et al. (2009))
Commitment to Outcome	Degree of intellectual or emotional bonding/ loyalty towards the outcome of the process (based on Duivenvoorde et al. (2009); Princeton University "About WordNet" (2010))

the primary criterion for judging the value of a LLCP. It can provide insights into (a) whether a LLCP can generate usable lessons learned, and (b) for which usage processes these lessons are suitable. If there are problems with using the collected lessons learned, further research may also reveal if and which characteristics of the collected lessons learned contributed to these problems.

However, this criterion has to be used with caution, because a LLCP that works well can still result in a lack of usage due to environmental factors. For example, leadership and incentives influence (and hinder) knowledge use (Kulkarni et al., 2007). Newell et al. (2006) argued that awareness about lessons learned and the opportunities they offer is a prerequisite for usage to take place. Also, for short-term studies the time-frame for studying the usage of lessons learned has to rely on serendipitous use. Thus, an absence of usage does not mean that a LLCP was of low quality.

Considering these difficulties with the actual usage of lessons learned as a criterion for judging the success of a LLCP, this criterion needs to be complemented with additional criteria.

As LLCPes studied in this thesis focused on facilitated collaborative processes and processes relying on lessons learned repositories, success criteria targeting facilitated collaborative processes (see, e.g., Duivenvoorde et al. (2009)) and knowledge management systems (based on Wu and Wang (2006) who based their research on the dependent variables suggested by (DeLone and McLean, 2003)) can provide a basis for judging the success of a LLCP. In the following, these criteria have been limited to criteria referring to the outcome of the process (and exclude those criteria that evaluate the process itself, such as perceived usefulness of a LLCP, and satisfaction with the process, see also Kolfschoten (2007); Brown et al. (2002)).

Outcome oriented criteria include whether a LLCP actually fulfilled its general task goal of collecting documented lessons learned, the (perceived) quality of these lessons learned, a commitment towards the outcome, and the participants' satisfaction with the results of a LLCP (Table 5.2 provides an overview of general success criteria relevant for this research).

Two of these outcome oriented criteria – the existence of documented lessons learned and their (perceived) quality – are important factors influencing the usage of lessons learned (see also Chapter 3 on page 33). The existence of lessons learned is a prerequisite for using lessons learned (see also Section 3.4 on page 40) regarding the relationship between quality and usage.

The (perceived) quality of lessons learned can be assessed in different ways. First, as part of general knowledge management efforts, their quality can be assessed from the perspective of information and knowledge quality. Furthermore, the quality may be judged by internal or external experts (e.g., during a verification process). The perceived quality relates to quality aspects of the collected lessons learned, such as their understandability and level of detail (see also Box 3.3 on page 43).

Satisfaction is an affective reaction reflecting the attitudes of a participant towards the outcomes of a process (e.g., the collected lessons learned) *after* it happened (based on Brown et al. (2002)). In information systems literature, it is one of the most common measurements of success (DeLone and McLean, 1992). For the success of LLCPes it provides a tentative indication when something is amiss with the results. (Briggs et al., 2012) hypothesized that a participant's satisfaction depends on the perceived likelihood and (decision) utility of achieving his or her private goals. Consequently, dissatisfaction can indicate that something is amiss with the collected lessons learned, and may relate to the challenges associated with LLCP: if we assume that participants have the implicit aim to avoid blaming and extensive complaining, lessons learned assigning blame or just being a complaint may result in dissatisfaction, for example. Further investigations into the causes for dissatisfaction are needed to fully understand its causes. Lessons learned may reflect more than one private goal, and the same goal may be achieved in different ways across a set of lessons learned.

This raises the question of how judgments of satisfaction are aggregated. For simple affective evaluations conducted in retrospect, initial research suggests that evaluations are not simply the average experience, but based on key features of the experience (Ariely and Carmon, 2000). For the peak-end rule, the dominating features are the experience at its most intense and at the end (Kahneman, 2000). The development of the affective experiences (from worse to better, or from better to worse) may also play a role (Ariely and Carmon, 2000). As a consequence, satisfaction as an aggregate may not indicate all sources of (dis-)satisfaction; lack of achievement on one private goal may be compensated by achieving other private goals, and the order in which individuals are exposed to lessons learned may influence satisfaction ratings. Also, the sources of (dis-)satisfaction may be unclear. For example, having unfulfilled high expectations may reduce satisfaction (see also Briggs et al. (2012) for on overview of phenomena influencing satisfaction). Similar difficulties regarding the aggregation of judgments may arise regarding the perceived quality of a set of lessons learned, as it is also an aggregate over a set of lessons learned. Overall, at this point, there is no evidence indicating whether these measures are based on an average measure for (read or collected) lessons learned, or whether particularly good or bad lessons learned have a higher (or lower) weight.

Chapter 6

Research Design

Building on the overall research design, this chapter creates a link between the extended model of LLCPes and the data collection and analysis, and addresses principles of research design in relation to LLCPes. It outlines how the basic and extended model (see Chapter 5 on page 67) were used to inform the creation of research instruments guiding the data collection (particularly the observation of LLCPes) and data analysis within the cases on lessons learned collection, and describes in detail how various research methods were used in the various cases (see also Section 2.3 on page 23 for the case overviews).

One objective is to show how issues of research quality were addressed. Therefore, it provides insights into how issues of validity and reliability were dealt with in this research. Box 6.1 on the next page outlines the main strategies for addressing validity and reliability. The sections on the various data collection instruments discuss issues with data quality that are particular to a type of data.

Furthermore, this chapter explains the choice of data sources and data collection instruments. Figure 6.1 on the following page creates a first overview of what type of instrument was used to collect data from which data source. Section 6.1 on page 79 explains the various types of research instruments used for data collection, while Appendix E.1 on page 281 provides a detailed overview of the qualitative data collected for each case (excluding survey data).

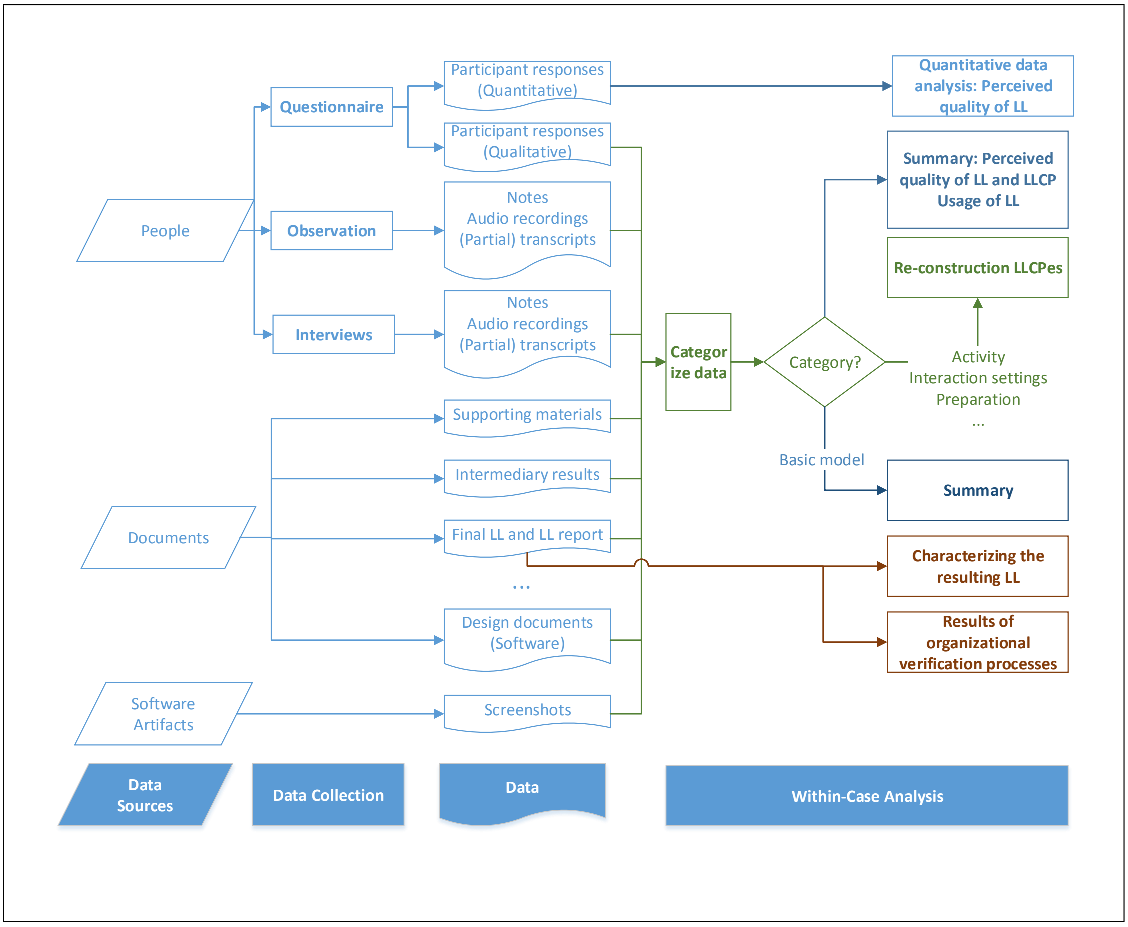

Figure 6.1: Outlining research instruments used for the LLCPes.

As shown in Figure 6.1, the data was analyzed with various methods for the within-case analysis (which are presented in Section 6.2 on page 85).

Box 6.1: Strategies for addressing validity and reliability issues

Validity issues (see also Miles and Huberman (1994, p. 279))

- addressing validity issues of a research method
- triangulation among methods and among data sources
- identifying areas of uncertainty
- considering alternative explanations (and process flows)
- creating an account that respects the temporal order of elements in the case context
- generalizing to theory and suggesting settings for further testing (Yin, 2008)

Reliability issues [a] (see also Miles and Huberman (1994, p. 278))

- describing the research instruments that were used (see the following sub-sections and Appendix D on page 265)
- maintaining a chain of evidence (e.g., listing sources for results regarding the process in the analysis documents) (Yin, 2008)

- basing the data collection and analysis on the basic or extended model of LLCPes, in order to clearly specify concepts used in the research instruments
- addressing reliability issues of a research method

[a]"Remember that a broken thermometer is 100% reliable – but not very valid" Miles and Huberman (1994, p. 278)

6.1 Data Collection Methods

In order to understand how LLCPes influence the quality of collected lessons learned, the research methods for this thesis needed to address the following two aspects

1. the LLCP and its environment
2. the (perceived) quality of the collected lessons learned and its relationship to the LLCP

This thesis used two main strategies for addressing the first aspect: observing actual LLCPes, or using interviews and documents to reconstruct LLCPes. Similarly, the second aspect was mainly addressed by asking participants of a LLCP about how they perceive the quality of the collected lessons learned and the LLCP, by gathering information about the actual usage of the collected lessons learned, and by analyzing and characterizing the collected lessons learned with regard to a limited set of quality criteria. Even though these strategies suggest that some research methods were applied only to collect data for one of these aspects, in practice most data types obtained insights into both aspects.

6.1.1 Interviews in General

In this thesis, semi-structured interviews were used as a versatile method to obtain both factual information and insights into intentions, expectations, or perceptions. They were used to collect data for three purposes:

1. to build up a description of a LLCP (in conjunction with documents to triangulate data) by gathering data about facilitated LLCPes that were not available for observation
2. to assess the quality of the collected lessons learned and the LLCP by
   (a) obtaining information about changes to the piloted processes, and the reasons behind these changes
   (b) revisiting cases, and explore if and how lessons learned were used in the case organizations
   (c) exploring perceptions of the quality of lessons learned (if surveys were not an option)
3. to obtain information about the environment of a LLCP

Data Quality. Semi-structured interviews resemble guided conversations. As guided conversions, they share may features of everyday conversations (Cohen et al., 2011) (e.g., mutual trust, discrepancies in mental models, ...). Accordingly, when using semi-structured interviews as a data collection method, threats to the validity of interview data originate in problems of meaning[1], problems of memory[2], and problems of omission and misrepresentation[3] (Bryman and Bell, 2007). Furthermore, tacit knowledge associated with the facilitation of LLCPes may be difficult to explicate.

In this research, these issues were partially addressed by careful selection of the interviewee (e.g., a facilitator with both theoretical background and knowledge and several years of experience was expected to provide a better description of an abstracted LLCP than one of the participants), and by building up a relationship with the interviewee prior to the interview.

In addition, problems of memory were partially addressed by

- using cues during the interview (this includes cues the interviewees provide themselves, e.g., their own documents or a demo of their own software artifacts used to collect lessons learned)
- asking about salient or recent events
- giving an interviewee the room to associate freely (this includes addressing less relevant or irrelevant information)

6.1.2 Observation – Being with People as They Collect Lessons Learned

For most cases in this research, observation was used to obtain a chronological record of how lessons learned were collected during the main phase of a facilitated process (excluding breaks). Ideally, the intended LLCP was known beforehand, and audio or video recordings were allowed during the LLCP. However, the case projects imposed restrictions, so that the researcher was confronted with three scenarios:

1. For DeepwaterCol I, the researcher was not allowed to make audio recordings, and the process was not known beforehand.
2. For DeepwaterCol II, the process was known beforehand from the observation of DeepwaterCol I, but audio recordings were not allowed.
3. For DepartmentCol I & II, a variation of the process was known beforehand (from the observations of DeepwaterCol I & II), and audio recordings were allowed.

[1] i.e., interviewer and interviewee may vary in the interpretation of key concepts due to different mental models

[2] i.e., interviewees may miss-remember or forget aspects of an event or behavior

[3] i.e., interviewees may leave out aspects of the question, do not answer a question at all, or do answer honestly. The causes for omission and misrepresentation are manifold and include a desire of the interviewee to present themselves in a good light as well as a tendency of interviewees to try and anticipate what the interviewer wants to hear (Cohen et al., 2011). Building up some trust prior to the interview may help to address these issues.

Particularly for the first case, it was important to use a manageable a-priori instrument that allowed the researcher to reconstruct the LLCP from notes. Research instrument C1 (Section D.1.1 on page 265) was used to guide the observational process. It is based on the notion of activities, and the basic model of LLCPes. As DeepwaterCol II and DepartmentCol I & II used a process design similar to DeepwaterCol I, the observation focused on *deviations* from and *additions* to the already observed process (still using the categories outlined in research instrument C1). In addition, after DeepwaterCol I & II, the researcher took additional notes from memory (in a separate section), and wrote an initial description of the abstracted process.

Data Quality. In general, the observational method utilized in this research can be classified[4] as

- naturalistic (the observation takes place in the observed groups own environment)
- non-participant (the observer does not participate in what is going on in the social setting)
- disclosed (people know that they are observed, and they have agreed to be observed)
- semi-structured[5] (an a-priori instrument is used to partially structure the observation, see also Cohen et al. (2011)).

Using naturalistic, non-participant observation influences the validity of data. On the one hand, compared to methods relying on interviews or self-reported data, observational methods lead to data on real behavior (Coolican, 2013), and avoid issues that arise because participants try to explicate what they do (Bryman and Bell, 2007). Furthermore, compared to participant observation, the researcher is less involved in the group (which helps to avoid the danger of 'going native', and improves internal validity) (Cohen et al., 2011)). On the other hand, disclosed observation may threaten the ecological validity of the data, because participants may change their behavior as a reaction to the presence of the observer (reactive effects), if they know that they are observed (Bryman and Bell, 2007; Cohen et al., 2011). Per contra, Bryman and Bell (2007) argue that people's awareness of the observer's presence is reduced by the requirements of the situation at hand. Furthermore, DeepwaterCol I & II had additional observers working for the organizations collecting lessons learned.

There are also some limitations to using observational methods, which resulted in areas of uncertainty. First, intentions and though processes behind behavior are rarely observable (Bryman and Bell, 2007). In the context of this research this affected insights into participant behavior. Importantly, some insights into the purpose of (a set of) activities could be inferred from the explanations that facilitators provided for participants. Second, by focusing on the present, the researcher may be unaware of important adjacent events (Cohen et al., 2011). For facilitated LLCPes, this affected the preparation and post-processing phases (activities for these phases were inferred during

[4]See (Cohen et al., 2011; Coolican, 2013) for these categories.

[5]The research instrument is semi-structured, because it makes only a few assumptions about the values encountered in each category. For example, the research instrument does not make any assumptions about the type of activities. Also, categories are may overlap.

the analysis phase). Last, observations conducted by a single researcher are selective (Yin, 2008). To steer this selective process, research instrument C1 was used. This instrument places a strong emphasis on the instruments and intermediary results during a LLCP, and less emphasis on participant behavior.

6.1.3 Documents as Data Sources

In this research, documents provided data that is used for three main purposes:

1. to build up a description of a LLCP (in combination with interviews providing additional insights)
2. to assess the quality of the collected lessons learned
3. to obtain information about the environment of a LLCP

Documents used for assessing the quality of the collected lessons learned were lessons learned reports or drafts of single lessons learned.

Documents collected to build up a description of LLCPes were documents outlining the design of the lessons learned repository in RepositoryCol, intermediary results from LLCPes (e.g., as exported documents from a GSS), documents for planning and supporting LLCPes (e.g., slides from a presentation), emails (e.g., regarding invitations of participants), meeting minutes, and the collected lessons learned (e.g., found in reports of LLCPes). Even though the main purpose of reports of LLCPes was to communicate the lessons learned themselves, they contained descriptions of the LLCP at various levels of detail (the level of detail being influenced by the intentions of the author(s)). Information about the environment could be found throughout these documents as well.

Data Quality. Documents as data sources have the advantage that they have not been produced specifically for the purpose of this thesis, and are therefore usually not subject to reactive effects (Bryman and Bell, 2007) (an exception may be the meeting notes, and email correspondence with the researcher). Nonetheless, documents do not contain the „unmitigated truth” (Yin, 2008, p. 105). Authors of documents have a point of view, which they want to get across to a specific audience. This may lead to omissions when describing the approach taken to collect lessons learned. Therefore, these documents were used in combination with each other, and to augment evidence from other data sources (see also Yin (2008)).

6.1.4 Software Artifacts

One of the strength of software artifacts as data sources is that they provide detailed insights into technological operations and interaction possibilities (similar to the physical artifacts that Yin (2008) considers as data sources, and assuming that the researcher has access to all features of the software). Therefore, the software artifact was an important data source in RepositoryCol, where it was used to obtain insights into which information was provided to the users, and into how users could interact with the software in order to collect lessons learned.

Data Quality. Similar to documents, software artifacts had not been produced specifically for the purpose of this research. One of the major weaknesses of software artifacts is that they do not provide information beyond the potential interaction with the artifact (see also Yin (2008) on physical artifacts). In the context of this research this resulted in uncertainty because questions of actual usage were often not addressed (e.g., on whether a user actually reads the given information, or in which work context the lessons learned were collected). Limited information about the usage of the artifact could be obtained through the surveys, and the resulting lessons learned, though.

6.1.5 Surveys

Surveys were mainly used to assess the successfulness of a LLCP from a participant's perspective. To a lesser extent, they were used to obtain information about the collection process and its environment, and about the respondents.

The surveys consisted of up to four parts: an introduction, questions regarding demographics, the main part focusing on quantitative data (see Table 6.1 for an overview of the variables) and some open-ended questions.

The quantitative questions utilized single items and (non-standardized) Likert-type scales (consisting of multiple items each measuring a small portion of the overall construct (Coolican, 2013)). These scales were based on pre-existing measurement instruments (see Wu and Wang (2006); Duivenvoorde et al. (2009); Briggs et al. (2003) for these instruments).

The items were measured using a seven-point Likert response format ranging from strongly disagree (1) to strongly agree (7), and „don't know" as an additional option.

Table 6.1: The construction of variables per case in the main part of the surveys

Variable	Applied in	Variable Construction
Perception of results		
Knowledge quality of collected LL	DepartmentCol InnovCol	Scale of 9 items Reduced scale of 6 items
Commitment towards outcomes	RefineryCol InnovCol	Scale of 5 items (Dutch version) 3 separate items
Satisfaction with the results	RefineryCol & InnovCol	Scale of 4 items
Context quality of LL	DepartmentCol InnovCol	1 item
Practicability of LL . . . recommendations	DepartmentCol InnovCol	1 item
Linkage of LL	DepartmentCol	1 item
Participation		
Use of LL repository/ participation in LLCP	DepartmentCol RepositoryCol	Items on actual activities

Data Quality. In general, surveys are considered more reliable than interviews (Cohen et al., 2011), particularly when comparing quantitative data from surveys with qualitative data from semi-structured interviews. With regard to validity, there are two issues to consider (Cohen et al., 2011):

1. For those who fail to return a questionnaire: would they have given the same answers?

2. Are the responses accurate, honest, and correct?

Regarding the first issue, surveys have a risk of low response rate or incomplete answers. As a result, survey results may show a volunteer bias (Cohen et al., 2011). This risk is increased by long surveys and difficult to understand questions (Bryman and Bell, 2007). The problem of low response rates was addressed differently in the various cases. In RefineryProject (as the first case this researcher did), a paper-based survey was handed out as the last step in the workshop, and respondents were asked to return it immediately. For MarineOrg, the survey was announced by the knowledge manager, followed by an invitation by the researcher (see Section D.1.4 on page 269). In addition, potential respondents were reminded to take the survey. For InnovOrg, the session owner and the facilitator managed the invitations to the survey, and the reminders to participate. In all three cases, the survey length was monitored and, if necessary, the number of items was reduced.

Regarding the second issue, (Yin, 2008) considers self-completion questionnaires to be one type of interview. As such, it shares some concerns regarding validity with structured and semi-structured interviews (e.g., regarding issues of memory, meaning, and omission). However, the severity of these concerns varies compared to interviews. First, the anonymity of a survey and the absence of an interviewer can have a positive impact on validity. Respondents are less likely to show social desirability bias (answer in such a way that the answers are considered favorably by the audience), and to under-report on sensitive and aversive issues (Bryman and Bell, 2007). In other words, answers may be more honest (Cohen et al., 2011). In the context of this research, this is relevant for criticism of the collected lessons learned. For open ended questions, problems of omission can be more severe than in interviews, because respondents are usually not prompted to elaborate on their answers (Bryman and Bell, 2007). For this reason, the surveys only had a few open-ended questions. In addition, if a respondent has difficulties answering a question, there is no interviewer present who can explain the concepts. For this reason, questions were reviewed with regard to understandability and ambiguity (see also below).

The use of single items using a Likert response format and pre-existing Likert-type scales also has implications for the validity and reliability of the collected quantitative data. One validity issue of the Likert response format is the acquiescence bias (i.e., the tendency to agree to a statement) (Coolican, 2013). While there are cultural differences in the size of the bias (with a higher tendency for an acquiescence response style in the Mediterranean compared to Northwestern Europe (van Herk et al., 2004)), there was no information on how severe the bias would be for a mainly Dutch population. Therefore, answers to Likert items and scales were taken at face value in this research. Another issue arises if a respondent is not familiar with a particular aspect of a lesson learned process or system. If the respondent is forced to provide an opinion in such a situation, it may affect the validity of that answer. This issue was particularly pertinent for the surveys administered during the pilot phase of MarineOrg due to the varying exposure of respondents to lessons learned and lessons learned processes. To address this issue the response format employed in the surveys included the option „don't know[6]".

Compared to single items, multi-item scales have the advantage that they can average out random measurement errors, differentiate between finer degrees of an attitude, and

[6]This option has implications for the data analysis, see Section 6.3 on page 87

are capable of representing complex theoretical concepts (Gliem and Gliem, 2003). Using pre-existing measurement instruments has the additional advantage that the instrument has undergone validity tests. Nevertheless, the validity (and reliability) has been established in a more general context and with a population that differs from the one encountered in this research. For example, Wu and Wang (2006) focused on users of established KMS in several organizations in Taiwan, while this research explores the attitudes of users of a piloted lessons learned repository in a few cases. Therefore, to improve the validity of responses in MarineOrg, the survey was reviewed first by a fellow researcher, followed by the knowledge manager and another employee at MarineOrg. Some of the reviewed items were also applied in InnovOrg (to maintain comparability). The final list of items can be found in Table D.2 on page 272.

6.2 Qualitative Data Analysis

This thesis used coding and within-case and cross-case displays to analyze the qualitative data.

In general, the analysis relied on a mixture of emergent concepts and a-priori concepts introduced in the extended model. Using an a-priori conceptual framework to guide data analysis had several reasons:

- A-priori instruments allow comparisons across cases and (if the same concepts were used) with prior studies (Miles and Huberman, 1994, p.35).
- A conceptual framework rooted in literature connects the analysis to a body of knowledge lying outside the data set (see Miles and Huberman (1994, p.87) for an illustration).
- If the framework is used well, it increases the reliability of findings (Miles and Huberman, 1994, p.35).

The concepts in the extended model are not particular to LLCPes. Such a general conceptualization indicates that these concepts need to be further developed inductively during the analysis (Miles and Huberman, 1994, p.61). As a result, some concepts were further refined (e.g., the activities). Alternatively, more specific concepts were drawn from literature (e.g., for techniques employed in the LLCPes, and for approaches to quality assurance).

The within-case analysis was designed to address the aim of this research to provide a transferable abstracted LLCP by analyzing in detail how lessons learned were collected.

To achieve these two objectives, the within-case analysis consisted of several steps (see Figure 6.1 on page 78 for the alignment of these steps with the data).

6.2.1 Categorization

First, a technique similar[7] to structural coding (see (Saldana, 2009)) was used to identify data relating to the aspects of the basic model, and to the quality of the lessons

[7] Structural coding focuses on research questions guiding in interview. This thesis uses the codes across all document to refer to the four aspects summarized in Chapter 6 on page 77.

learned and the LLCP. In addition, information on activities and interaction settings were identified and demarcated to support the re-construction of LLCPes. Appendix D.4 on page 277 provides details of this analysis step.

6.2.2 Summaries

Data on the basic model (the environment, the participants, general information on instrument types, and the task goal or purpose of the LLCP) were summarized.

Similarly, data relating to the success of the LLCP (e.g., the usage of the lessons learned, and the perceived quality of lessons learned), as well as qualitative (relevant) data from the survey were summarized.

6.2.3 Re-constructing LLCPes

The flow of activities was analyzed using time-ordered matrix displays (Miles and Huberman, 1994, p. 119), with activities as columns and concepts describing an activity from the extended model as rows of the display (see Appendix D.5 on page 278). General information on instruments, tools, quality assurance, and participant behavior and interaction setting could be integrated into this matrix. Overall, this analysis step resulted in a time-line of activities.

In parallel, a tabular overview of the interaction settings (using the dimensions outlined in Box 5.3 on page 74) was created.

Furthermore, for salient intermediary outcomes, simple aggregates were used in order to obtain an impression of the effect of the activities, and to check whether these outcomes matched the expected results of sequences of activities (expectations were set based on task goals, e.g., an activity aiming to select a topic for discussion should result in a topic that is then discussed).

Last, the observable input for the activities were mapped to the preparation activities (see Table 5.1 on page 72), in order to infer which additional preparation activities occurred prior to the main phase of a facilitated process.

Based on this process tracing, and a theoretical understanding underlining that certain types of instruments can have a particular effect, propositions are formed stating that particular instruments shaped the outcomes of the LLCPes. However, it should be noted that this is still a tentative inference, indicating that a particular instrument has the potential for a certain effect. This holds particularly for instruments that are not well understood in literature, or where the effects are difficult to observe (such as the effect of ground rules, or the effect of some quality assurance measures applied during the LLCPes). A single case (or even a few cases using the same instruments) are insufficient to generalize these effects to other LLCPes.

6.2.4 Characterizing the Collected Lessons Learned

The characterization of the resulting lessons learned used two types of instruments: a predefined instrument for characterizing the set of lessons learned, and an emergent one focusing on idiosyncrasies of lessons learned collected via a particular LLCP. The first instrument

- assessed the size of the set (i.e., the lessons learned were counted, usually using demarcations already found in the case)
- categorized them as positive, negative, or other
- categorized them as referring to (a) the product created in a project or department, or (b) the process used to create that product

The second type of instruments started with the structures of lessons learned introduced in the respective LLCP, and inductively described how the lessons learned fit into this structure.

6.3 Quantitative Data Analysis

The analysis of quantitative data involved treating missing item scores in Likert-type scales that resulted from the option „don't know" in the survey design, and choosing descriptive and inferential statistics for single items using a Likert response format and Likert-type scales.

There are several methods to treat missing item scores in Likert-type scales (see Roth et al. (1999) for an overview). Two methods are to remove the respondent from the study (listwise deletion) or any analysis using that scale (pairwise deletion in, e.g., paired t-tests). However, these methods can result in a loss of power and accuracy. Alternatively, for Likert-type scales, missing item scores can be replaced with item means or person means. (Downey and King, 1998) argued that, due to the high correlation of items in a scale, person means approximate an estimation based on the correlation of items (known as regression imputation). Both the item mean and person mean method lead to good representations of the mean and Cronbach's alpha when less than 30% of the data are missing (Downey and King, 1998) (though inter-item correlations, and therefore reliability, increased when using person means). However, Roth et al. (1999) suggested avoiding item means, because this method ignores individual differences, and may result in a bias for regression weights between variables (not items) and a reduction of covariance. In contrast, they noted good empirical results for their data for the person mean method. Therefore this research replaced missing scores using person means if the number of respondents with missing data was equal to or less than 30%, and the number of missing item scores was 25% or less (per scale).

Following Jamieson (2004), individual items using a Likert response format result in ordinal data, because the response categories suggest an order, but the interval between response categories cannot be assumed to be equal. Therefore, this research used the median as a measure of central tendency and quartiles as a measure of dispersion.

However, unlike Jamieson (2004), this thesis follows Carifio and Perla (2008) in that Likert-type scales can, in principle, be analyzed parametrically. Therefore, the scores of a scale were transformed into mean scores[8] per person. Due to the low number of responses, and asymmetric distributions, the median and quartiles were used as measures of central tendency and dispersion.

[8]The mean score was used instead of the sum of item scores in order to maintain comparability between scales with different number of items.

6.4 Reporting Results

Each individual LLCP can be considered a study on its own, and, following Yin (2008, p. 56), should be reported as individual reports complemented with a cross-case report. Reporting the cases in individual chapters has the advantage that each chapter would contain a detailed description of an abstracted LLCP that can be transferred to other organizations or used in future research such as field experiments. For this reason, this thesis follows Yin's suggestion.

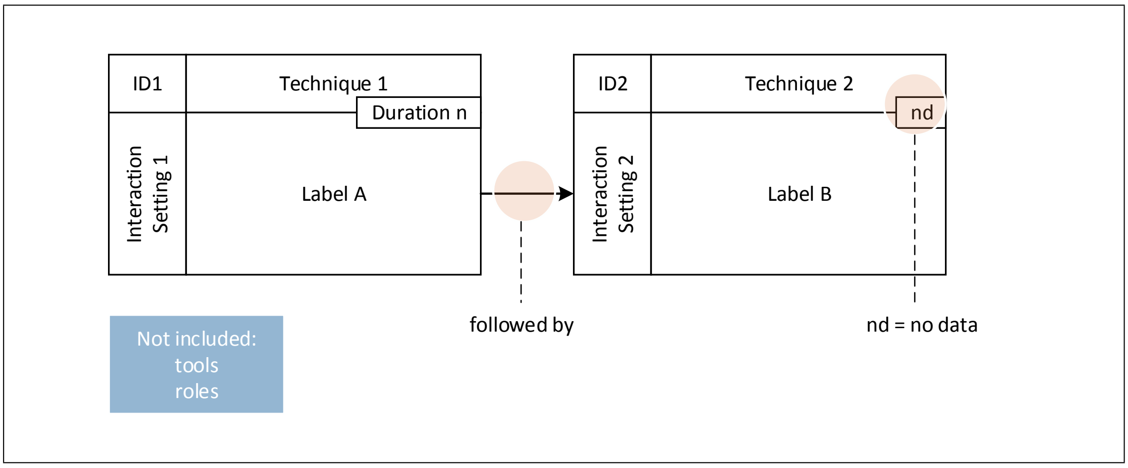

Figure 6.2: Visualization of activities

However, while LLCPes with larger differences between each other are reported in separate chapters, LLCPes with almost the same abstracted LLCPes are reported in the same chapter. As a consequence, DeepwaterCol I & II and DepartmentCol I & II can be found in Chapter 7 on the next page and Chapter 9 on page 127, respectively.

For each report of an abstracted LLCP, the chapter first provides an overview of „input" factors associated with the components in the basic model. It then explains the unfolding of the abstracted LLCP using the extended model, and includes intermediary results as well as participants' behavior. If a facilitated approach was used to collect the lessons learned, concepts specific for repositories (Section 5.3.2 on page 74) were not used in the chapter, and vice versa. For facilitated processes, the activities of the main phase are visualized using a flow of activities (see Figure 6.2 for a sequence of two activities).

Each activity is depicted with a label (based on the task goal), identification (ID), its technique, and its interaction setting. If a temporal sequence of activities can be identified in the data, this sequence is indicated through arrows.

The results on the process are then followed by a characterization the set of collected lessons learned. Last, an evaluation of the LLCP or the process output is presented.

Chapter 7

DeepwaterCol

DeepwaterCol I & II were facilitated collaborative LLCPes focusing on retrospectively collecting lessons learned from a mega-project. Both cases are LLCPes that collected lessons learned at the end of the project. The lessons learned were collected by the contractor (MarineOrg), but the LLCPes also involved participants from the client organization. As the abstracted processes were very similar, the sections present both DeepwaterCol I & II, and highlight differences regarding the second process.

7.1 Basic Model (DeepwaterProject)

This section provides a short overview of the components of the basic model (namely the participants, the task goal and purpose of the LLCPes, and the instruments and supporting roles), and summarizes identified environmental influences on the LLCPes.
The environment. Actual evidence regarding influences of the environment on the LLCPes is sparse, as the main data was collected through observation of the process itself.

The lessons learned were collected in retrospect about a year after the project execution phase involving MarineOrg had ended. Both LLCPes took place in a meeting room in the headquarters of MarineOrg in The Netherlands. The events in the project influenced the participants' behavior: throughout the LLCPes, participants in various roles referred to the events and situations in the DeepwaterProject (but not to other projects, see also Section 7.2.2.3 on page 98). The LLCPes might also have been influenced by a hypothetical future event: at the time of the LLCP MarineOrg and the client organization considered it a possibility that the DeepwaterProject would be followed by a similar project. The similarities extended to the location, main stakeholders (particularly MarineOrg and the client), and technology.

The intention to collect lessons learned was formed in the environment, as it was part of the contract between MarineOrg and the client organization. Also, project management was willing to engage an external, experienced facilitator to guide through the LLCP.

Participants. The participants contributing to DeepwaterCol I & II were technical experts (subject matter experts for the respective theme of the LLCP), project engineers, and participants responsible for quality assurance in the project Only employees from the client organization and from MarineOrg participated. Overall, there were eight participants in DeepwaterCol I, and ten participants (the majority being associated with the client organization) in DeepwaterCol II. In addition, there were several observers[1] present in both LLCPes (at least two in DeepwaterCol I, and four in DeepwaterCol II)

Purpose and task goal. One purpose of the LLCP was to prepare for the possibility of a similar project. In order to achieve this purpose, the task goals of the LLCPes were to collect lessons learned about a *technical* aspect of the project in DeepwaterCol I, and lessons learned about the *supply chain management* in DeepwaterCol II. For both LLCPes, this task goal included summarizing lessons learned, and giving recommendations *as a starting point*. An additional task goal of the LLCPes was to celebrate the success of the project.

Instruments and supporting roles. DeepwaterCol I & II were facilitated by an external[2] facilitator experienced in LLCPes. The main instrument used in both cases was an abstracted LLCP that was adapted to the specific case settings (see Section 7.2 for details).

The tools were mainly based on ICT: a screen, laptops, and software tools were used for giving presentations, and a laptop and a spreadsheet were used to take notes that were not immediately shared with the group. In addition, the facilitator used a whiteboard and pens for documenting contributions that were visible to the whole group. Last, two audio-recorders were used to record the oral group discussions.

7.2 Lessons Learned Collection Processes

This section presents the processes used in DeepwaterCol I & II using the concepts developed in the extended model. In both cases a facilitated approach was used to collect the lessons learned. Therefore, concepts relating to repositories (Section 5.3.2 on page 74) were not used in this section. The LLCPes consisted of several preparation activities, a main phase for collecting lessons learned, and post-processing activities for creating drafts of these lessons learned.

7.2.1 Preparation Phase

The following box summarizes the input categories identified for DeepwaterCol I & II. In general, the potential input categories suggested in Table 5.1 on page 72 could be identified for the LLCPes. Only the task goal of the process, some of the instruments, and the selected participants varied between DeepwaterCol I and II. The results of the other preparation activities indicate that some of these results could have been created as part of the preparation on a project level (see, e.g., identified themes), or as part of designing a project-independent abstracted LLCP.

[1] In other LLCPes in DeepwaterProject, additional observers from a similar upcoming project were invited to sit in on the LLCP.

[2] The term external refers to the organizational affiliation of a facilitator. An external facilitator is not affiliated with the stakeholders of the project.

Box 7.1: Input for the main phase in DeepwaterCol I & II

Items in italics were specifically created for or adapted to DeepwaterCol I and or II. The other items indicate that the input may not have been created specifically for one (or both) cases.

Identified themes Prior to DeepwaterCol I & II, several themes for LLCPes in the DeepwaterProject were identified. Two of these themes (a specific technical theme and supply chain management) were assigned to the observed LLCPes (one per case).

Goal of the process The purpose of the LLCPes was the same in both cases, and presumably defined for the whole project. In contrast, the task goals referred to the respective theme of the LLCP, and therefore varied between the two cases (see also purpose and task goal in Section 7.1 on page 89).

Designed process As shown in the following sections, Deepwater I & II used similar *abstracted* processes as their input: the LLCPes shared a sequence of abstracted activities (albeit with some variations in the configurations), an agenda, and also used the same conceptualization of a lesson learned. This abstracted process was based on a preexisting design, and adapted to requirements in the DeepwaterProject. In particular, activities were removed from this preexisting design. Gathering metadata and keywords for the collected lessons learned was an abstracted activity that was considered out of scope for the observed LLCPes, for example. It should be noted that parts of the abstracted process such as the questioning structure and the ground rules seem to have their origin in after-action reviews (see, e.g., Milton (2010); USAID (2012)). After-action reviews were developed for team learning in the US military (Schindler and Eppler, 2003), but in DeepwaterCol I & II they were appropriated to organizational learning.

Selected (and informed) participants The participants were individuals with technical expertise matching the themes for DeepwaterCol I & II, as well as individuals involved in the management of the project. The participants were affiliated with two stakeholders in the project: the client organization and MarineOrg. One participant per case had to prepare and give a presentation on the theme of the LLCP[a].

Selected ground rules A selection of ground rules used in both LLCPes are listed in Box 7.2 on page 93. In general, they targeted group norms and values during a LLCP, set expectations on what to include as lessons learned (e.g., positive *and* negative lessons learned), and also included a rule on how lessons learned would be published.

Facilitator The same facilitator moderated both observed LLCPes. He was selected based on his affiliation with a consultancy organization. This consultancy organization had prior experience in lessons learned, and at least one member of the organization was in the network of the knowledge manager.

Location The LLCPes used a traditional meeting room design (see Justice and Jamieson (2006)). The actual meeting room had two areas for presentations, one at each table head. The room was too small for the number of people (participants and observers) in the LLCPes, so that some observers had to sit in front of one these areas of presentation.

Selected and organized tools The same tools were used in both DeepwaterCol I & II (see also Section 7.1 on page 89). Some of these tools were part of the equipment of the room (e.g., a screen and a whiteboard) and therefore did not need to be organized; others were organized by the facilitator (e.g., the audio recorders).

Prepared instruments for main phase The preparation of instruments used some of the outputs from the various activities in the preparation phase. Most notably, presentations introducing the respective themes were created for the opening phase (see Section 7.2.2.2 on the following page). Instruments such as the specification of a lessons learned format (see Box 7.3 on page 95) or the selected techniques and most of their configurations did not vary between DeepwaterCol I & II.

[a] There was no data available on who invited the participants, or whether other participants were asked to prepare for the LLCPes

7.2.2 Main Phase

The main phases of DeepwaterCol I & II took place one after the other (with a 15 minute break between the two main phases). They were planned for 2 hours each, but their actual duration deviated from this plan: DeepwaterCol I started late (for about 20 minutes) and took about 1:55 hours, whereas DeepwaterCol II took 2:15 hours, thus finishing late.

7.2.2.1 Interaction settings

DeepwaterCol I & II used six interaction settings (see Table 7.1 on the facing page for an overview). There were no variations in the interactions settings between the two cases.

All interaction settings were co-located and synchronous, taking place in the meeting room arranged during the preparation activities. The seating arrangement in Deepwater-Col II reflected organizational affiliations[3]: participants from the client organization and from MarineOrg were seated at opposite sides of the table. Participants had name tags (displaying their name and affiliation) on the table in front of them, which made them easily identifiable.

The interaction settings orchestrated who could contribute at what time, and who could interact with whom. With the exception of the *face to face (F2F) group (DP)*, the interaction settings constrained the interaction between participants. On the extreme end, the *silent work (DP)* and *independent work* were both interaction settings in which participants performed a task while not being expected to interact with each other at all. During the silent work (DP), participants were required to perform a task simultaneously with the other participants; during independent work participants were free to choose when to perform a task. The independent work was also the only interaction setting where all participants left their seats.

In the *quick round*, participants were asked to make their contributions sequentially, using the seating order as the ordering criterion. In the *broadcast* setting, one participant stated contributions, with the other participants were restricted to listening. The *lecture style* was a typical interaction setting for giving presentations in a meeting. It was based on a broadcast, but still allowed for some interaction between participants (e.g., when asking a presenter some questions).

7.2.2.2 Opening phase

During the opening phase (see Figure 7.1 on page 94), the participants introduced themselves, and were introduced to the concept of lessons learned. **DPO1** used a quick round with semi-structured questioning to introduce the participants to each other. In the context of techniques, this thesis defines[4] a question as any speech act requiring a participant to supply information, or to think about what information could be supplied.

[3]For DeepwaterCol I, no detailed notes on the seating arrangements were taken.

[4]This definition was based on a notion in linguistics, where a question can be defined as „an illocutionary act that has a directive illocutionary point of attempting to get the addressee to supply information" Loos, E. E., Anderson, S., Day, D. H. J., Jordan, P. C. and Wingate, J. D. (Eds.) (2004). As such, a question is a speech act that is not tied to a specific grammatical form. It can take the form of prompts (e.g., „event: "), or, in an extreme cases, the form of silence (see also (Bryman and Bell, 2007, p. 486)).

Table 7.1: Interaction settings in DeepwaterCol I & II

	Lecture style	Silent work (DP)	F2F group (DP)	Broadcast	Independent work	Quick round
Expression mode (participants)	verbally	none	orally	orally	in writing	orally
Anonymity	no	yes[a]	no	no	partially[b]	no
Interaction among participants	yes	no	yes	one way	voluntary[b]	yes
Sub-grouping	no	-	no	no	-	no
Simultaneity	turn taking	-	turn taking	no[c]	-	sequential
Relative Location	co-located	co-located	co-located	co-located	co-located	co-located
Synchronicity	same time	same time	same time	same time	same time	same time

[a] BUT: identifiable, individual contributions shared in following activity

[b] participants could observe each other and interact while writing down a contribution, but most were busy with food and beverages during the break

[c] just one participant contributing

Semi-structured questioning was a technique involving a set of questions, generally allowing a participant to freely answer the question, and allowing for follow-up questions. In collaborative settings, several *answering patterns* were allowed for this (and other) questioning technique(s). First, participants could just think about the answers without communicating them (silent answers). Second, each participant could provide his or her own answers to the complete set of questions (individual answer sets). The order of the questions and answers could vary between participants (see also Bryman and Bell (2007, p. 213)). Third, questions could be answered with the first good answer given by the participants (first answer counts). In this response pattern, the answers should complement each other, so that altogether the group answered the complete set of questions. Last, for each question the group could jointly develop a complete answer (joint answer). Combinations of these response patterns might also exist.

In DPO1, each participant was asked to briefly state a name, an organization, and his or her reason for participating in the LLCPes (using the individual answer set). Overall, participants gave concise answers.

Furthermore, the facilitator provided an introduction into the LLCP in **DPO2 to DPO7** using *presentations*. Presentations were a (general) technique for presenting a topic (by one or more presenters) to an audience in a semi-structured way. The presentation usually had a discernible outline and premeditated content, but parts of it could be adapted to the situation at hand. Consequently, the exact content could vary between several runs of a presentation.

The main input for these activities were presentation materials created during the preparation activities (see Box 7.1 on page 91), and the set of tools used to support presentations (see Box 7.1 on page 91).

Box 7.2: Excerpt of ground rules (DeepwaterProject)

Expectation Setting: Boundaries for LL

- Capture both positive *and* negative LL

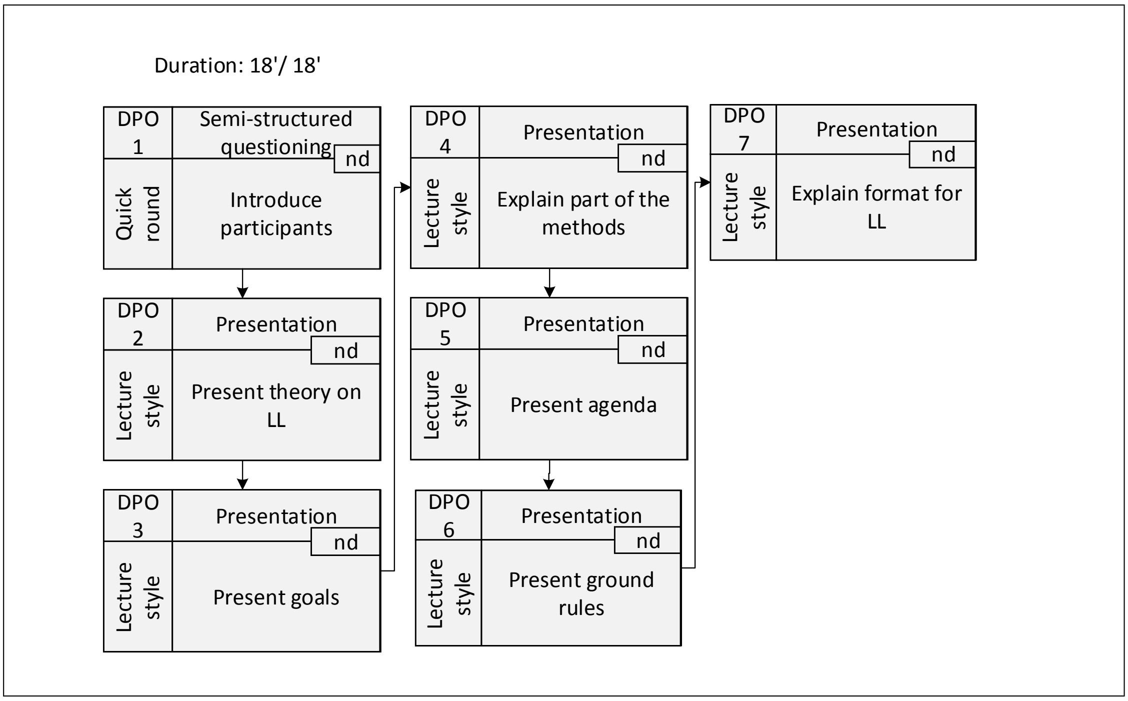

Figure 7.1: Process model for the opening phase of DeepwaterCol I & II. Measurements of duration first state the duration in DeepwaterCol I, followed by the duration in DeepwaterCol II.

- Applicable to the future
- Technical *and* softer issues should be addressed

Group Norms and Values

- No ranks in the room – everybody is equal
- Disagreement is healthy
- NOT a blaming session
- Be open
- Let yourself be facilitated

Expectation Setting: Post-Workshop Rules

- LL are not published without somebody looking over it

Headings and emphasis were added by the researcher.

During these activities participants were informed about the theoretical background of learning from lessons learned in an organization (specifically referring to a learning loop that allows organizations to learn for future projects), the theme-independent task goals of the LLCP (see also Section 7.1 on page 89), an agenda outlining intermediary tasks for the main phase (pointing to DPD1, DPD3, DPD4, and the extraction of lessons learned in DPD5 to DPD9), and a presentation of ground rules (see Box 7.2 on the previous page for a selection). Last, the facilitator presented the format of a lesson learned (see Box 7.3 on the facing page).

Box 7.3: Lesson learned format (DeepwaterProject)

- Title
- Expectations – what should have happened?
- Event Description – what did happen?
- Differences between them
- Root Cause – why?
- Lesson – what did we learn?
- Impact – money, time, resources, efficiency
- Contact at MarineOrg

Throughout the opening phase, the concept of lessons learned was introduced. In DPO2, lessons learned were conceptualized through their purpose, whereas, in DPO7, they were conceptualized through their structure. In DPO6, boundaries of the concept were addressed: lessons learned could be both positive and negative, and they could pertain to both technical and softer issues (with the latter including, e.g., the way of communication or management issues). In addition, desirable attributes of lessons learned were stated: lessons learned should be applicable (DPO6), they should be understandable, and they should not contain too much detail (both in DPO3).

Similarly, the facilitator communicated what participants could expect during and after the main phase. The task goal (DPO3) and agenda (DPO5) introduced activity sets and the main task, whereas the explanation of the approach (DPO4) outlined how lessons learned were collected (namely in a spreadsheet, and making them understandable for everyone). The ground rules in DPO6 outlined behavioral norms relevant for the whole main phase. The facilitator also explained that the perception of the importance of a topic might have changed, and he asked the participants to use the insights they had at the time of the LLCP.

7.2.2.3 Core phase

The core phase (see Figure 7.2 on the next page) consisted of four sets of activities:

1. Introducing the theme for the core phase (DPD1)
2. Identifying and selecting topics for lessons learned (DPD2 to DPS1)
3. Collecting lessons learned on the selected topics (DPD5 to DPD9)
4. Collecting positive experiences (DPD10)

Introducing the theme for the core phase During the first activity in the core phase (**DPD1**), a presenter introduced the theme for the LLCP (using a presentation technique, tools for presenting a set of slides, and the lecture style interaction setting). In DeepwaterCol I, the presenter chose to review the technical work performed during the project; in DeepwaterCol II, the presenter outlined some of the challenges encountered during

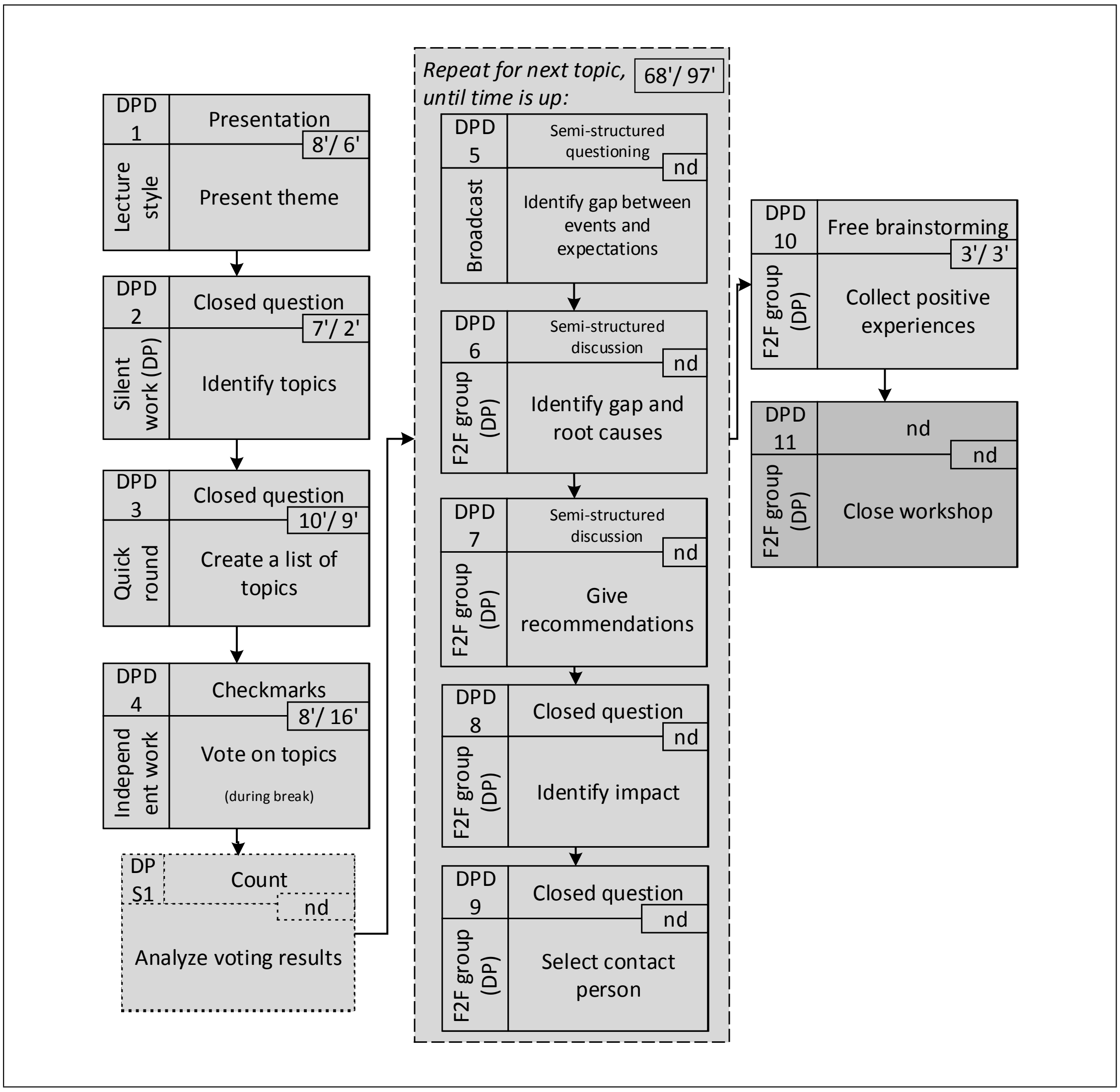

Figure 7.2: Process model for the core phase and closing phase of DeepwaterCol I & II. Measurements of duration first state the duration in DeepwaterCol I, followed by the duration in DeepwaterCol II.

the project. All in all, these activities rooted the general task of collecting lessons learned in a specific theme, and linked the theme to events and situations encountered in the project.

Identifying and selecting topics The second set of activities in the core phase focused on the identification and selection of topics for lessons learned. This set consisted of three consecutive collaborative activities for identifying topics (DPD2), creating a list of the identified topics (DPD3), and voting on these topics (DPD4). Afterwards, the voting results were analyzed in a supporting activity (DPS1). The task goal for this set of activities was to select the most important topics for further discussion. More precisely, the facilitator referred to DPD2 as „identify high grade areas to discuss", and to the other activities in this set as „Select top 10 to 20" in the agenda.

To achieve these task goals, **DPD2** used a closed question. Closed question (based on Bryman and Bell (2007, p. 210)) was a technique involving a single question that could be answered in one or two short sentences. The answers were expected to be brief, and elaborations or clarifications of the topic were discouraged. In DPD2, the participants were asked for two topics (ideas) for lessons learned using silent answers.

Regarding time management, the facilitator stated „We write down one. If there is enough time, we write down the second one", thus preparing participants for the possibility that only one topic might be used in the next activity. This option was not used in either case, however.

In **DPD3**, two quick rounds were used to collect the topics identified in DPD2: the participants orally stated a topic, and the facilitator documented each topic in the form of a short title on a whiteboard. The technique was therefore almost the same as in DPD2, with the answering pattern changed to individual answer sets. Regarding deficiency discovery and fixing, the facilitator used his control over the pen and direct questions (in the line of „What should I write down?") to obtain concisely phrased topics. Following Kolfschoten et al. (2011), this can be classified as input monitoring, where the contributions of participants are monitored, and a participant is asked to provide a correction if a quality criterion is not met.

The participants generally gave no indication on whether the collected topics addressed positive or negative experiences. Only in DeepwaterCol I there was a short exchange where participants pointed out that two sequential topics addressed positive experiences. Also, in DeepwaterCol II, participants used the option to pass instead of adding a topic, resulting in 16 instead of 20 topics on the final list. In line with the restrictions of the technique, participants did not attempt to clarify or elaborate they meaning of a topic, and other participants did not ask questions about the stated topics. Also, no attempt to add more than two topics per participant was noted.

Next, **DPD4** utilized the *checkmarks* technique[5] combined with independent work to order the topics. Checkmarks was a voting technique (see Briggs and de Vreede (2009) for a variation of the technique that encompasses both the voting and the aggregation of the votes). Each participant was given a fixed number of votes, which they could distribute over the ballot items according to a voting criteria and additional constraints on how to distribute their votes. In both LLCPes, such additional constraints were added with the intention to prevent deficiencies.

Regarding the configuration, the topics listed in DPD3 were used as ballot items and the importance of a topic for the project was used as the voting criteria. Each participant was given five votes. During DPD4, the facilitator also informed the participants that the topics with the highest votes would be discussed first, thus stressing the purpose of the activity. Participants were provided with pens to place the votes (in the form of dots or lines) next to the topics. As a consequence, participants could observe how others had voted, and late voters could see which topics had already accumulated how many votes. Thus, the votes might not have been independent of each other. Constraints on how to distribute votes varied between both cases. In DeepwaterCol I, the facilitator instructed the participants to ignore the votes on the whiteboard, and to form their own judgment (thus addressing the risk of dependent votes). Participants were also implicitly allowed to place multiple votes on a single item (no instruction provided). In contrast, the facilitator added a constraint in DeepwaterCol II by instructing the participants to

[5]This voting technique is also known as cumulative voting, and used in elections.

vote for five different items, not just for the topic they had contributed[6].

Last (**DPS1**), the facilitator used a *count* to obtain a rank order of the topics. This technique involves creating a score for each ballot item by counting the number of votes it received. The order of the ballot items was implied by the descending order of these scores. In contrast to the technique described in Briggs and de Vreede (2009), the variation used in the observed LLCPes did not include a verbal summary of the voting results. In DPS1, the facilitator indicated the order of the items by noting the score next to each topic.

Both in DeepwaterCol I & II, this activity set resulted in a list with 16 topics (on average 2 topics per participant in DeepwaterCol I, and 1.6 topics per participant in DeepwaterCol II). These topics were listed in the order they were contributed, and therefore their position on the whiteboard correlated with the seating order. The number of votes per topic ranged from 0 to 6 in DeepwaterCol I, and 1 to 8 in DeepwaterCol II.

Table 7.2: Number of topics per workshop

	Gathered	Discussed	% of gathered topics
Technical theme	16	5	31
Supply chain	16	6	38

Table 7.3: Topics discussed in the workshops (DeepwaterProject)

Technical theme				Supply chain			
Topic ID[a]	Themes (in discussion)	# Votes	Duration: DPD5 to DPD9 (min)	Topic ID	Themes (in discussion)	# Votes	Duration: DPD5 to DPD9 (min)
11	planning	6	27	3	client, sub-contractors	8	20
4	sub-contractor selection	5	13	1	*client, procurement*	7	14
6	planning, communication	5	11	6	vendor selection	4	14
2	expertise, quality control	4	6	10	documentation	4	14
16	*planning, communication*	4	11	13	contracting strategy	4	13
				14	(location), contracting	4	12

[a]refers to the ordering of the topics on the flip chart

Collecting lessons learned on selected topics (DPD5 to DPD9) The third set of activities (**DPD5** to **DPD9**) focused on collecting lessons learned for a sub-set of the identified topics (the task was labeled „extract lessons learned" in the agenda).

The main tools during these activities were two audio recorders and a prepared (digital) spreadsheet, for recording the participants' oral contributions and taking written

[6]This actually results in a different voting system, also known as block voting.

notes, respectively. In addition, the whiteboard continued to show the list of topics together with the voting results, and the screen again displayed the lessons learned format (see Box 7.3 on page 95 for the actual format).

The instructions around tools, and their use during the process also contained aspects relating to deficiency prevention. First, by taking notes and creating an audio record of the participants' contributions, the facilitator ensured that he did not have to rely on his own memory for creating a first draft of the lessons learned (see also (Bryman and Bell, 2007, p.489) for similar quality issues in focus groups and interviews). However, creating audio recordings raised concerns about having sensitive information recorded (evidence of these concerns was that the researcher was not allowed to record the discussions). These concerns were addressed by informing the participants of the (limited) role of the recordings in drafting lessons learned, and assuring them that the recordings would be deleted after creating these drafts. Last, the clearly visible list of topics and the lessons learned format in combination with oral instructions during the LLCP are instances of constraint emphasis, a modification of a technique in which important constraints for contributions are stressed orally and in writing (see also the constraint emphasis modifier in Kolfschoten et al. (2011)).

The display of topics and voting results were used as a coarse grained structure for the following discussions: the group did not extract lessons learned from a fixed number of topics, but instead iterated through the list of topics in descending order, with lack of time for further discussion as a criteria for ending the loop. The participants' behavior and effects of that behavior changed with subsequent iterations. On a content level, the participants occasionally referred back to previous iterations, pointing out some overlap between causes leading to a topic. These overlaps reduced discussion time, as the details were not repeatedly explored. Furthermore, in later iterations, the facilitator uttered less oral instructions. Instead, the participants seemed to be able to guide the discussion themselves, while supported by the displayed lessons learned format. This suggested that participants learned how to analyze a topic as a group, and that consequently the efficiency of the activities improved. These two observations might also explain why the discussion time per topic showed a tendency to decrease (see Table 7.3 on the preceding page for an overview).

Complementing the coarse grained structure provided by the list of topics, the lessons learned format provided a more fine grained structure to guide through the discussion of each selected topic. To begin with, **DPD5** consisted of two sub-activities (with Figure 7.2 on page 96 showing the interaction setting and technique for the second activity). In the first sub-activity, the facilitator identified the participant who had originally suggested the topic, either based on his memory and the position of the topic on the whiteboard or through a closed question. DPD5 further utilized a broadcast setting and semi-structured questioning (with first answer counts) to outline the context of a lesson learned in the form of events, expectations, and differences between these. The technique was configured with the second to fifth question in the lessons learned format, resulting in an initial account of the main events and expectations pertaining to the topic from the perspective of the participant who had suggested the topic.

In **DPD6**, the facilitator changed the interaction setting to a F2F group, and the technique to a *semi-structured discussion*. A semi-structured discussion was a technique that allowed participants to share diverse ideas, information, and opinions about a topic. It was semi-structured in that the participants were discussing aspects of a topic following a set of semi-structured questions. It allowed a wide range of interaction between participants, including helping each other, extending or correcting contributions of others, asking for clarifications, as well as voicing objections and criticism to the contributions of other participants. As such a discussion included the possibility for (unresolved) conflicts.

In DPD6, the semi-structured discussion continued with the set of questions posed in DPD5, with an additional question on potential root causes for explaining the differences between events and expectations. The discussion still relied on a set of questions, but multiple participants were allowed to share their perspective on the discussed topic and to criticize or complement each other's viewpoint. Optionally, the discussion can result in concluding answers to the questions. Overall, DPD6 allowed the group to complement, extend and challenge the initial description, and to elicit perceived causes for the gap between event and expectations.

DPD7 continued the semi-structured discussion by asking the participants to suggest recommendations for future projects.

During DPD6 and DPD7, various instances of deficiency discovery and fixing could be observed. First, several interventions used input monitoring. For example, the facilitator instructed the participants to clarify what they meant with an expression („We tried to defy the laws of [..]"), or to elaborate what they meant with a general term. In one instance, he ostentatiously took his hands off the keyboard, and informed the participants that he could not understand the discussion anymore, followed by the instruction to explain things to him (thus substituting for the readers of the final lessons learned). All of these interventions used understandability and an appropriate level of detail as quality criteria. Furthermore, in the context of identifying root causes, a distinction of root cause versus symptom („Are we talking about the symptoms?") was used as a means to evaluate the quality of the contributions. In contrast to input monitoring, a quality evaluation requires the participants to judge the quality of the contributions, which allows them to confirm or deny that there was a deficiency in the first place. Similarly, the facilitator suggested a summary and checked with the participants whether this summary described a cause.

There are a few things to note regarding the actual participant behavior in DPD6 and DPD7. First, during the discussions, participants had no access to the project documentation. As a result, the description of events, expectations, and the causal analysis had to rely on the participants' memory. In this context, participants also showed uncertainty about what had happened or was documented in the project, often leading to clarifying statements from other participants.

Second, the activities were not as clearly separated as suggested in Figure 7.2 on page 96. For instance, the discussion around the first topics and the lessons learned format suggested a clear separation of DPD6 and DPD7. For some topics the identification of recommendations actually occurred in separate discussions. However, the behavior of the participants indicated that these activities could overlap as well. Most prominently, recommendations were sometimes developed together with the root causes in DPD6, and were just repeated in DPD7 in order to clarify what the group considered the conclusions of the discussion. Also, in both DeepwaterCol I & II, participants remarked that a topic was already (partially) addressed in the discussion of a previous topic (these topics are emphasized in Table 7.3 on page 98). More precisely, these topics had root causes overlapping with those of the previously discussed topics, indicating that the discussions of topics were not strictly separated.

Third, there were several instances revolving around the relationship of MarineOrg with the client organization. In one instance in DeepwaterCol II, the participants shared insights on whether recommendations would be acceptable for both the client organization and MarineOrg („[X] does not work for [client organization]. We should be doing [Y].”), and used these insights to propose an alternative recommendation. For one topic participants from MarineOrg suggested how the client organization could improve. For another topic, the participants derived recommendations with MarineOrg and a client organization as the joint addressee, thus acknowledging that any improvements in future projects would need a cooperation between both stakeholders. All in all, the participants acknowledged that improvements in future projects could need a cooperation between both stakeholders, and that both stakeholders could be responsible for implementing these recommendations.

Last, the discussions around recommendations provided some insights into how participants’ communicated their recommendations. Participants used counterfactual statements, focusing on (hypothetical) actions and resources that could have led to different outcomes *in the past*. Examples include „We could have done [X]. We didn’t have the foresight to do it.”, or „We didn’t have [list with X]. I think if we had, we could have done [Y].” Conversely, one participants phrased his personal conclusion focusing *on the future* („A LL for me is ‘next time I do X, Y, Z’.”). A third pattern for communicating recommendations utilized the imperative (e.g., „Record the actual work performance; don’t let the fairy tale stand up.”). Notably, none of these recommendations simply focused on not repeating actions from the DeepwaterProject, but suggested alternative courses of action.

Next (**DPD8**), the facilitator switched to a closed question by asking for the impact of the lesson on the project. Finally, in **DPD9**, he asked for somebody from MarineOrg to take on the responsibility to verify the correctness of a draft version of the gathered lesson learned.

This set of activities involved interventions focusing on time management. It was announced that the topics would be addressed in descending order (using the number of votes as the ordering criterion) and that only the most important topics would be discussed. The discussion of each topic resulted in intermediary output that could be handed over to the post-processing phase. Thus, the facilitator could adjust the number of discussed topics to fit the time available in the main phase. In addition, in DeepwaterCol II, the facilitator adjusted the duration of the main phase by announcing about 30 minutes before the planned end of the session that he would continue the workshop (only) 15 minutes into the lunch break.

The activity set had two major outcomes. First, the number of topics was reduced from 16 to 5 (a reduction to 31%) and from 16 to 6 (a reduction to 37%) in DeepwaterCol I & II, respectively. In both LLCPes, participants did not discuss topics with less than four votes. Second, the activity set resulted in notes and recordings for each remaining topic, which was used in the post-processing phase to create drafts of the lessons learned. These topics encompassed technical issues, as well as non-technical issues such as lack of expertise or project management with a relation to the technical theme. This inclusion of non-technical issues was consistent with the expectations of the facilitator, who had observed similar behavior in other projects (and therefore other organizations).

Table 7.4: Number of words in a LL (DeepwaterProject)

	Topic ID	Event	Expectation	Impact	Recommen-dations	Root Causes	Sum
Technical theme	11	161	73	20	130	49	433
	4	107	30	21	64	16	238
	6	118	37	30	31	20	236
	2	69	19	20	28	14	150
Supply chain	3	93	65	16	132	27	309
	6	77	32	15	67	16	197
	10	76	16	20	79	11	201
	13	70	14	26	67	22	190
	14	80	20	16	81	19	211

To conclude the core phase in **DPD10**, the facilitator asked the participants to quickly contribute positive experiences and quick wins for other projects using a **free brainstorming**. Free brainstorming (see Briggs and de Vreede (2009) for a variation of the technique) was a technique for sharing as many ideas as possible on a cue (e.g., a question) in a given time frame. Participants could use each other's ideas.

During DPD10, participants shared experiences relevant for particular contractors and suppliers. In contrast to the more elaborate collection of lessons learned, the sharing of positive experiences was brief and unstructured: neither additional questions nor a change in interaction were used to further structure this activity.

7.2.2.4 Closing phase

Except for a brief leave-taking in DPD11, activities relating to the functions of a closing phase could not be observed in DeepwaterCol I & II. It should be noted, however, that one of the core functions of the closing phase, detailing responsibilities for actions performed after the main phase, was already addressed in DPD9.

7.2.3 Post-processing Phase

The post-processing phase aimed to create a first draft of the from the LLCPes based on the audio recordings and notes taken during the main phase.

In this phase, the writers had to adapt the lessons learned format to the one used in MarineOrg (see Chapter 8 on page 109 and the following section for details), and topics with shared root causes were merged into one lesson.

In addition, the knowledge manager at MarineOrg transferred the lessons learned into the lessons learned repository, and extended the lessons learned with required metadata. Finally, the contact persons identified in DPD9 were asked to verify the draft.

7.3 Characterizing the Collected Lessons Learned (DeepwaterCol)

The set of lessons learned. DeepwaterCol I & II resulted in 4 and 5 documented lessons learned, respectively. All lessons learned were *negative* and contained process knowledge.

Structure of the lessons learned. In general, the lessons learned followed the questioning structure used during the LLCPes (see Box 7.3 on page 95). This structure was adapted to fit the format used in lessons learned repository piloted in MarineOrg (see Table 8.2 on page 117): the differences between event and expectations were summarized as part of the event under the sub-heading „fundamental difference".

Observations regarding the drafted lessons learned are summarized in Table 7.5 on the following page, while Table 7.4 on the preceding page outlines the extent of documentation for the various fields of the lessons learned format used in the repository (excluding the categorization of the lessons learned).

The fields event, impact, expectations, and root causes all contributed to an understanding of the problems experienced in the DeepwaterProject. Causal attributions were described under root causes as well as the differences between events and expectations. The lessons learned, and to a lesser extent these differences, focused on preventing the events and the impact in future projects.

Recommendations. It is noteworthy that none of the lessons simply negated an activity or state in the DeepwaterProject (e.g., they did not state to obtain more experience, or to improve communication), which would have been the simplest recommendations for negative lessons learned. In general, the lessons learned outlined recommendations on a project level, not on an organizational level. Furthermore, at least 6 of the lessons learned contained recommendations that had not been followed in the DeepwaterProject. This suggests that the lessons contained alternative, hypothetical, courses of actions.

7.4 Evaluation

The evaluation for DeepwaterCol I & II included data from MarineOrg's internal verification process (see Section E.4.1 on page 286 for the criteria used in that process), and an interview with the knowledge manager. Participants (or other employees) were not available for an assessment of the collected lessons learned.

DeepwaterCol I & II produced 4 and 5 well-structured lessons learned, respectively, all relating to their respective themes. As such, the LLCPes were able to fulfill their task goals.

Verification. Two of these lessons learned (22%) went through MarineOrg's internal verification process and were approved, indicating that these lessons learned were of acceptable quality.

Usage of the collected LL. Even though the knowledge manager considered the collected lessons learned to be valuable learning opportunities for the organization, she could not report on any usage for the collected lessons learned, particularly on the organizational level.

The lack of usage was not due to a lack of opportunity for using the lessons learned

Table 7.5: Characterizing drafted lessons learned (DeepwaterProject)

LL format	Referring to	Content
Title[a]		Theme of the LLCP, followed by the topic identified during the LLCP.
Project[b]	originating project	DeepwaterProject
Event description: what did happen[a]	originating project	One or more states or activities detailing negative effects or situations in the project
Expectations: what should have happened?[a]	generalization of project (project of this type, size, etc.)	Needs or requirements relating to, e.g., contracts for sub-contractors, or to how to create a schedule for the project.
Differences between them[a]	originating project	Lack of desirables that, in the participants' opinion, could have prevented the events: all differences were phrased as or could be rephrased as "a lack of" something (e.g., a lack of shared understanding between specific stakeholders regarding certain risk areas).
Root causes: why[a]	originating project	Mainly lack of desirables that, in the participants' opinion, could have prevented the events if present. LL typically referred to MarineOrg's (and optionally the client's or a sub-contractor's) lack of foresight or lack of experience with the type of project or aspects of the technical theme, but also included not involving certain people, communication issues, or project constraints as a root cause.
Lesson: what did we learn[a]	future projects	Enumerated list of recommendations. At least 6 lessons contained items that had not been followed in the originating project. Lessons with communication issues and a lack of involvement as root causes provided recommendations detailing how to avoid these root causes. Root causes focusing on MarineOrg's inexperience and project constraints were associated with recommendations that did not simply try to prevent the root cause (i.e., recommended gaining more experience), but suggested courses of actions with the purpose of preventing the events and achieving the expectation.
Impact: money, time, resources, efficiency[a]	originating project	High-level effect in the DeepwaterProject. The impact typically referred to project management success criteria (schedule, cost or quality; safety or efficiency were not mentioned).
Created by[b]	employee of MarineOrg	Main creator: Lessons learned coordinator (member of the organization responsible for the LL processes) Alternative: one participant who added the draft, and extended it on his own[c]
Modified by[b]	employee of MarineOrg who worked in the originating project	Supposed[d] to be the participant identified during the LLCP

[a]As introduced in the opening phase

[b]Explicitly stated only in the LL application

[c]Observed for LLCPes in the DeepwaterProject, that were NOT DeepwaterCol I or II.

[d]Due to a lack of data on the participants identified during LLCP, this could not be verified independently.

on an organizational level, as similar lessons learned from another project could be used in MarineOrg. Rather, the lack of usage was attributed to three causes. First, the contact person identified in DPD9 was made responsible for suggesting actions. However, it was rather difficult for these contact persons to develop actions (the contact persons did not seem have a „helicopter view" needed to identify actions). Second, the individuals who would be responsible for this type of usage had moved on to other positions in the organization. Last, the LLCP seemed to have set wrong expectations, as its task goal was focused on collecting lessons learned on a specific theme, and not on turning these lessons learned into actions to be used on an organizational level (see also Section 7.1 on page 89).

A review for updating management documentation was stated as a planned usage of the lessons learned.

7.5 Discussion and Conclusions (DeepwaterCol)

This chapter presented a detailed analysis of two cases based on the basic and extended model of LLCPes. The two cases had almost the same underlying abstract LLCP. This abstracted process seemed to have been followed as salient intermediary outputs matched their task goals, suggesting that

The abstracted LLCP can account for the intermediary outcomes observed in the process.

The adaptation of the process to various themes and the needs of MarineOrg provides tentative indications that the abstracted LLCP was a designed process, though, without a design specification, we cannot know whether the design actually encompassed all aspects presented in this chapter, e.g., with regard to quality assurance.

The evaluation of the LLCPes indicated that these processes can be considered a success in the sense that they actually created well-structured lessons learned outlining what happened in the project, why these things happened, previously unknown requirements and needs for a project of this type, and what to do differently, e.g., in order to achieve these additional requirements and needs. Thus, both the how and why aspects of process knowledge were addressed (see also Box 3.3 on page 43). However, even though the main task goal was achieved, the challenge to collect positive lessons learned was not met (see also challenge **Out4** on page 61). Furthermore, the recommendations focused on preventing problems in future projects, and not on how to reactively deal with these problems. Thus, the collected lessons learned were not applicable to all usage scenarios. Interestingly, some lessons contained alternative courses of actions, for which the DeepwaterProject did not deliver evidence regarding their effectiveness.

Overall, the LLCPes were successful in collecting process knowledge, and (potentially untried) recommendations for preventing mistakes in future projects. They were unsuccessful in creating positive lessons learned.

Key characteristics of a lesson learned are the result of a complex interplay between the environment, the participants, and the abstracted LLCP used to collect lessons learned (see Chapter 4 on page 45). When transferring the abstracted process to other opportunities for collecting lessons learned, this raises the question to what extent the characteristics of the collected lessons learned were actually a function of the abstracted LLCP.

There are indications that the abstracted process shaped the (set of) collected lessons learned. This influence extended to several characteristics of the lessons learned. First, the identification and selection of topics (DPD2 to DPS1) restricted the *topics* to those that fit the theme and were perceived as having a high impact on the project.

Second, the application of the lessons learned format in DPD5 to DPD9 was reflected in the *structure* of the drafted lessons learned. While the lessons learned contained some refinements and was adapted to fit into MarineOrg's repository, major deviations from the main structure (e.g., different structures, or lessons learned omitting some of the prescribed parts) were not be found, indicating that the abstracted activities in the main phase (DPD5 to DPD9) were instrumental in shaping the initial structure of the lessons learned.

Furthermore, using the list of topics for controlling the duration of the overall discussion during the collection activities also restricted the *quantity* of collected lessons learned. In essence, the abstracted process used a (shifting) deadline, and the scope of the LLCP was adapted to fit within the time frame allocated for the LLCPes.

Last, these activities may also have influenced other characteristics of the final lessons learned, such as their *understandability* and *level of detail*, as both characteristics had been addressed by the interventions for deficiency discovering and fixing.

The individual taking on the role of the facilitator might also have influenced understandability and the level of detail. The facilitator was not involved in the project, and it can therefore be assumed that he knew considerably less than the participants about the themes of the LLCPes (both with regard to professional knowledge, and specific events in the project). Consequently, there was a lack of common ground (referring to, e.g., shared professional knowledge and knowledge of past events, as well as information about the current situation (Eysenck and Keane, 2010, p.421)) between participants and the facilitator. During the collecting of lessons learned in DPD5 to DPD9, the facilitator basically asked the participants to consider him as a listener, and he also ostensibly indicated that there were issues with the understandability of the discussion. While awareness about his lack of knowledge and his intervention might have led to participants trying to make their contributions understood by the facilitator, resulting in additional explanations ultimately improving the understandability of the lessons learned, the actual effects could not be traced through the process. Thus, while the selection of the facilitator (and implicitly a selection of differences in knowledge) may have influenced the understandability and specificity of the lessons learned, further research is needed on this mechanism in the context of LLCPes.

Thus, the abstracted LLCP shaped key characteristics (quantity, topics, structure, understandability and level of detail) of the collected lessons learned.

In contrast, the answers to the questions posed in the lessons learned format followed some patterns that could not be attributed to the guidance provided in the process. First, even though the abstracted process indicated that lessons can be based on positive experiences, only negative lessons were collected in in DPD5 to DPD9. Second, the lessons learned format simply asked for differences between events in the originating project, and expectations. The drafted lessons learned phrased these differences systematically as a lack of desirables. Next, the abstracted process, as summarized in this study, did not prescribe how to derive the lessons themselves, while the lessons consistently recommended actions to *prevent* the events encountered in DeepwaterProject. Only one lesson also recommended an action for monitoring and intervening. Furthermore, the abstracted process did not prescribe the relationship between root causes and lessons. The drafted lessons followed the pattern that lessons suggested actions for preventing root causes if these root causes had not been addressed already (MarineOrg had gained experience with a certain project type in the DeepwaterProject itself) and if they could be changed (constraints for the project could not be changed). Last, even though the drafted lessons learned all focused on the process used to create an installation (the product), it remains an interesting question to what extent the abstracted process actually contributed to this tendency.

There are several explanations for these patterns. The patterns may have been a result of influences of the environment (e.g., national or organizational cultures), of factors associated with the participants (e.g., preconceptions about what constitutes useful lessons), or even the interaction of process characteristics with participant characteristics (resulting in Dutch people speaking English). However, the patterns may also have been the result of an abstracted process. The observations in this study could not be complemented with transcripts of the actual discussions. Therefore, it is likely that some interventions have been missed, and it is possible that these interventions influenced one or more of the outlined patterns.

Importantly, the abstracted LLCP cannot explain these patterns regarding differences between events and expectations, root causes, and recommendations. Also, further research is needed to determine whether the focus on process knowledge and negative lessons learned was affected by the abstracted process.

It was not the *presence* of the instruments that shaped any characteristics of the collected lessons learned, though. Rather, apart from being a listener (see above), the facilitator fulfilled two functions previously researched in the context of group decision making. *Guidance* (i.e., directions for participants enabling them to execute an abstracted process) and *restrictiveness* (i.e., a manner of limiting a group's interaction to those indicated by the abstracted process) were found to mediate the effect of abstracted decision making processes on decision quality (Wheeler and Valacich, 1996). Furthermore, facilitators were effective in restricting the interactions of participants (Wheeler and Valacich, 1996).

In DeepwaterCol I & II, these mediating factors could be observed as well. The facilitator and written instructions (e.g., the lessons learned format) provided guidance (see, e.g., the opening phase). They also restricted the participants' actions to keep them in line with the techniques and their configurations. It is unknown whether participants followed these restrictions during the whole process. For example, it could not be observed whether the participants followed the voting instructions of not voting only for their own suggestions, or what effect the ground rules had on the main phase. Nevertheless, major deviations (such as using different techniques to collect the lessons learned, and additional or missing activities), could not be observed when comparing the two cases, suggesting that the participants were to a large extend limited to the sequences, activities, and techniques prescribed in the abstracted LLCP.

Guidance and restrictiveness provided by the facilitator and written instructions may have mediated the effects of the abstracted LLCP.

Chapter 8

RepositoryCol: Collecting lessons learned through a KMS

RepositoryCol was the only case in this thesis using a lessons learned repository for collecting lessons learned. This repository will be referred to as the lesson learned application in this chapter. The case study used a rather narrow definition of a lesson learned, limiting them to recommendations for future projects and excluding the events and experiences that let to these recommendations. To maintain remain consistent with the other case studies, the term lesson learned in this chapter refers to recommendations and context such as the experiences (as a unit), and (in contrast to MarineOrg's use of terms) uses the term recommendation for the narrow notion of a lesson learned.

8.1 Basic Model (RepositoryCol)

The environment. Several factors pertaining to the environment of the LLCP could be identified.

First, RepositoryCol was designed to *continuously collect* lessons learned from the sub-department during a pilot phase for the lessons learned application. This pilot phase lasted for about five month. Tan et al. (2006) suggested that such a continuous collection of lessons learned could help to avoid potential memory issues by reducing the time gap between having and documenting experiences (see also challenge **Part1** on page 63).

Second, the content of the LL was indirectly influenced by the engineering tasks performed in the department.

Furthermore, the organization (as part of the environment) supported RepositoryCol, and provided the custom-made software application that formed the basis of the LLCP, as well as additional lessons learned processes (also supported by the application). These processes included accessing lessons learned, the verification of the content of a lesson learned, decisions on recommendations suggested for changes on the organizational level, the implementation of these recommendations, and archiving lessons learned. Participants could inform themselves about these processes using the homepage of the lessons learned application as well as a user guide for that application. There is also tentative evidence that upper management as well as the department head were supportive of the lessons learned efforts in MarineOrg.

Furthermore, three factors could be associated with MarineOrg's culture. First, a fear of repercussions after coming forward with observations or mistakes had been reduced as a result of changes made in the context of a safety program in MarineOrg, which stands in contrast to challenge **Part3** on page 63. Employees were perceived as having an open attitude towards learning from mistakes, resulting in a willingness to admit them and work towards preventing them in the future. Second, the intention to collect lessons learned during the pilot phase was threatened by an expected high workload, and competing tasks. Interviews with participants in the context of DepartmentCol also indicated that documenting knowledge (as opposed to sharing it orally) could present a hurdle to collect lessons learned via the application.

Participants. Overall, 13 individuals employed in one department in MarineOrg were explicitly informed that they could contribute their lessons learned through the lessons learned application (see also Section D.1.4.1 on page 269). During the pilot phase, this number fluctuated: one additional employee participated in the LLCP, and two employees were no longer available at the end of the pilot. The potential participants were mainly male, with an engineering background (see also Section 8.4.1.1 on page 121).

The interviews with participants prior to the LLCP indicated that the conceptualization of and experience with lessons learned varied considerably among participants, which is, in general, a characteristic of informal lessons learned processes (Gibson et al., 2007). The participants had also been introduced to a previous version of the application, but had no additional training on the concept of lessons learned, and on quality criteria for lessons learned.

The interviewees expected to cover process knowledge (e.g., the use of equipment, analysis methods, or the skills of personnel and sub-contractors) in the lessons learned. Product knowledge was not mentioned among the topics expected to be covered in lessons learned.

Regarding issues associated with participation in the LLCP, the interviewees showed a positive attitude towards lessons learned, and a general support for the lessons learned efforts in MarineOrg. Nevertheless, the positive attitude towards lessons learned did not consistently result in the intention to collect lessons learned during the pilot phase. For example, the department head did not expect to contribute lessons learned during the pilot phase due to a lack of opportunity resulting from his position in MarineOrg. He also indicated that the time he could spend on activities associated with the pilot would be limited. In contrast, the senior engineer expected to be involved in the collection of lessons learned, but expected lessons learned to be collected at the end of a „job".

Overall, the interviewees expected their actual participation in the LLCP to be influenced by the time available, their role in the organization, and the availability of events serving as a basis for lessons learned. The latter was expected to be influenced by the temporal relation of a LLCP to the work performed in the department.

Task goal and purpose. The purpose of the LLCPes can be considered on two levels: why collect lessons learned in MarineOrg, and why collect lessons learned using the particular LLCP employed in RepositoryCol.

Regarding the first question, the purpose of the collected lessons learned was to positively influence the performance of (unspecified) parallel, and future projects. This was to be achieved by applying lessons learned in these projects or on an organizational level (e.g., cross-tender, or cross-department) after the pilot phase in order to prevent reinventing the wheel, and to prevent repeating or re-introducing mistakes made in a project. Lessons learned were not just conceptualized as explicated knowledge, but also envisioned as a tool to identify individuals with relevant experiences for a problem, who could help with adapting the lesson learned to a particular context. Here, the expected usage of lessons learned combined notions of explicating knowledge with social networking[1]. In addition, the lessons learned were expected to serve as a knowledge base for new employees.

Regarding the second question, the purpose was focused on understanding the added value of the piloted lessons learned application for MarineOrg by assessing whether the quality of lessons learned would improve, evaluating the usability of the software application, and assessing whether recommendations targeting the organizational level would lead to an active implementation of lessons learned.

The task goal for the participants was to collect a lesson learned from a successful or unsuccessful project. During the pilot phase, it emerged that it was not part of the task to collect non-conformances with procedures, or safety issues (as there were different systems with different consequences already used in MarineOrg), or to document one person's frustration or a blaming game.

Instruments and supporting roles. During the pilot phase, the participants were supported by the knowledge manager, who worked in close proximity to the participants and could answer questions and provide help regarding the usage of the lessons learned application.

This newly developed lessons learned application was the main tool in RepositoryCol. It was based on SharePoint, and its functionality was considered „as simple as possible" due to its early development stage. Details on the functionality of this application can be found in Section 8.2 on the next page. This application served as a database for lessons learned, and supported their storage and dissemination[2].

Throughout the case study, *access* to this application was limited to (a) employees working in two technical departments in MarineOrg, and (b) individuals in supporting or research roles. Even after the case study, access to lessons learned stored in the application would be restricted to employees of MarineOrg. However, exported lessons learned might be shared if necessary. Thus, contractors or clients would not have the option to access all lessons learned of MarineOrg in order to prevent lessons learned being used against the organization (e.g., in case mistakes documented in a lesson re-occurred during a project). During the pilot phase, the application was maintained on a separate server, and not linked to or integrated with other intranet applications of MarineOrg[3]. This resulted in a slower performance compared to similar applications in MarineOrg.

Additional (software) tools used in RepositoryCol supported accessing this application (i.e., a browser) as well as reading a user guide and a file containing suggestions for improving this application. To invite participants and communicate during the pilot

[1] Newell et al. (2006, p. 182) suggested complementing documented lessons learned with the development of personal networks in order to increase the effectiveness of efforts. MarineOrg suggested an avenue for actually achieving such a combination, though further research on the effectiveness of this approach is still needed.

[2] This included an export function for sharing lessons learned with project partners (clients, contractors, . . .), who did not have access to the IT system.

[3] MarineOrg planned to integrate lessons learned into their internal homepage after a successful pilot.

phase, participants could use tools for sending and receiving emails.

8.2 Lessons Learned Collection Process

RepositoryCol used of two types of activities (see Figure 8.1 for the process model): activities for obtaining information (RCI1 to RCI5) allowed a participant to inform him or herself about the concept of a lesson learned, the lessons learned processes, and about how to use the application. Analysis results pertaining to these activities are presented in Section 8.2.2 on the next page. The authoring activities (RCA1 to RCA8, presented in Section 8.2.3 on page 115) focused on how to collect a single lesson learned starting with its identification.

All activities involved at least one participant in the role of an author. The authors could choose the interaction setting (see the following section for some options). Apart from four authoring activities, the activities presented in Figure 8.1 were optional (indicated by dashed lines around an activity). The authors could also choose the order of the activities, switch dynamically between activities, or replace suggested activities (or its techniques) with their own. Nevertheless, the structure of the tools used for authoring a lesson learned suggested an order for the activities (indicated by the arrows in Figure 8.1).

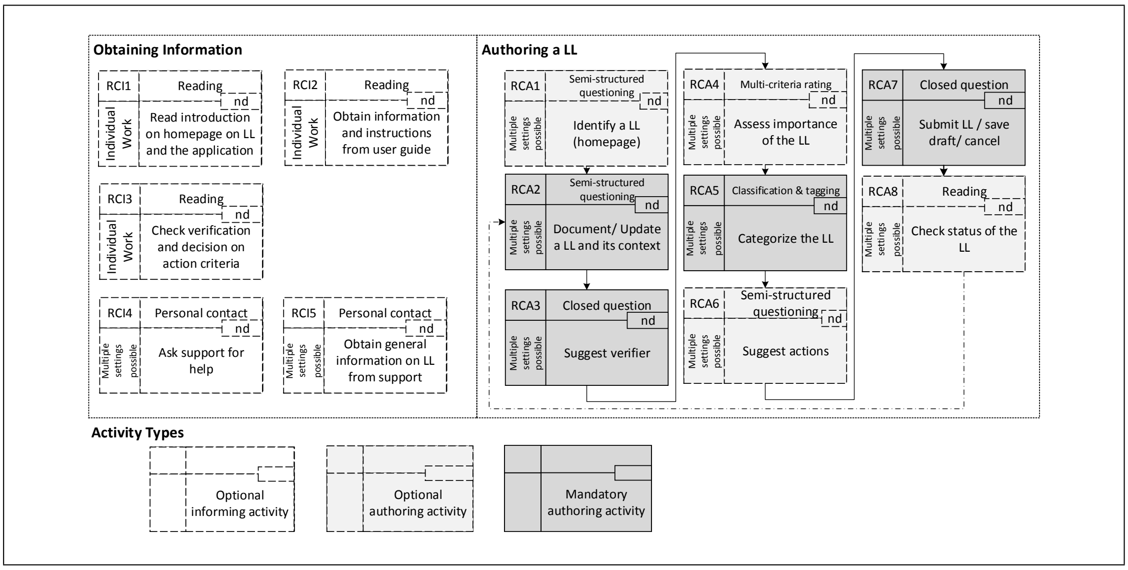

Figure 8.1: Process model for collecting LL (RepositoryCol)

The activities could usually be performed in various interaction settings (see Section 8.2.1).

8.2.1 Potential Interaction Setting

In RepositoryCol, authors had great freedom in choosing an interaction setting. The knowledge manager suggested three interaction settings that could be used (see Table 8.1 on the facing page for an overview) during the authoring activities.

First, *individual work* was a non-collaborative activity that entailed one author sitting at his or her desk and documenting a lesson learned via the application.

Asynchronous self-organized group work involved a group of authors working on a draft of a lesson learned at different (not overlapping) times. The lessons learned application supported this interaction setting through the option to have multiple authors of a single draft of a lesson learned. Links to such a draft could be shared, but a more elaborate workflow (e.g., asking a potential participant to contribute to a lesson learned) was not supported[4].

Last, *synchronous self-organized group work* involved a group of authors working together in a meeting room in order to write down a lesson learned. In this setting, it was optional to use the lessons learned application, as participants could choose to, e.g., take notes and transfer those later on. The knowledge manager emphasized that synchronous self-organized group work was preferred to asynchronous self-organized group work, but that, due to constraints in the organization (e.g., working in different locations), it might not be feasible to use this interaction setting.

Even though asynchronous and synchronous self-organized group work were considered potential interaction settings, the instructions for participants did not suggest working in a group, and there was no evidence that these interaction settings were actually used. Also, the potential interaction settings may not be limited to these three options.

Table 8.1: Potential interaction settings in RepositoryCol

	Individual work	Asynchronous self-organized group work	Synchronous self-organized group work
Expression mode (participants)	in writing	in writing	verbally
Anonymity	no[a]	no	no
Interaction among participants	-	yes	yes
Sub-grouping	-	no	choice of participants
Simultaneity	-	turn taking	choice of participants
Relative Location	-	choice of participants	co-located
Synchronicity	-	asynchronously	same time

[a]The author was automatically stored by the LL application.

8.2.2 Obtaining Information

In **RCI1** to **RCI5**, authors could obtain information on lessons learned and the lessons learned processes. Sources for this information included documents (the homepage of the lessons learned application used in RCI1, a user guide used in RCI2, and templates provided by the application used in RCI3), and personnel responsible for providing support during the pilot phase (see RCI4 and RCI5). These two types of sources were accompanied by two different techniques.

In **RCI4** and **RCI5**, the main technique involved *personal contact* – authors needed to take the initiative and ask the support for help with any question or problem they

[4]Initial attempts to implement a workflow in the LL application contained too many bugs and were discontinued.

encountered. The personal contact allowed the information obtained through this activity to be tailored towards the needs of a particular author. The supporting personnel worked (physically) close to the participants. Thus, participants actually engaged in RCI4 and RCI5, particularly when encountering problems.

In contrast, all activities for obtaining information from documents (**RCI1** to **RCI3**) used a variation of *accessing* and *reading* as a technique. Accessing the various documents showed differences with regard to the effort participants had to exert. The homepage (RCI1) was displayed upon navigating to the lessons learned application. In contrast, the user guide (in RCI2) was a separate document that had to be downloaded and opened, while the criteria in RCI3 were only accessible (via a tab) in parallel to the main authoring activities (RCA2 to RCA8).

The authors were free to choose a particular reading technique – or not to read a document at all. While there is no data available on how authors actually read the documents, literature suggested that several techniques were available. For example, documents can be printed, and read in-depth, which is usually accompanied by annotating and highlighting (Liu and Ziming, 2005). Alternatively, authors can use keyword spotting or skimming (i.e., they scan for relevant information, and read selectively, while omitting words, paragraphs, or pages) (Liu and Ziming, 2005; Duggan and Payne, 2011). Duggan and Payne (2011) found through eye-tracking analysis that, using this technique, a reader spends more time on important than on unimportant information. The user guide supported skimming by emphasizing information in the text (using bold font, bullet points) or through visualizations. Considering that authors could choose whether to open a document, and even if opening it, which parts to read in what depth, the authors may or may not have been familiar with particular parts of the content of the documents.

Box 8.1: General information about LL (RCI1)

In essence, lessons learned are a tool to close the feedback loop between projects:

- Documented project knowledge gained from both **successful** and **unsuccessful** projects that once re-used can impact the organization by improving the cross-project learning, and with that positively impact the performance of the current, other and future projects.[a]

This SharePoint application has been developed to support the lessons learned process, as shown in [a figure depicting a flow chart with the main lessons learned processes in MarineOrg].

[a] This definition was first published in Barney (2011).

Documents were configured with various content. In RCI1, the homepage described the concept of a lesson learned (see Box 8.1). This conceptualization stressed the purpose of lessons learned (see also Section 8.1 on page 109), and the role of the lessons learned application in supporting the processes.

The introduction of the user guide in RCI2 repeated the information presented in RCI1. Furthermore, RCI2 informed about the purpose of the pilot phase (see also Section 8.1 on page 109), organizational matters during the pilot phase (such as how to contact the support or how to provide feedback), and technical limitations of the software application. Next, the functionality of the home page was introduced, and a learning loop illustrated how lessons learned from one project can lead to improved practices in the same or future projects. The learning loop was used to justify continuous documentation of lesson learned and a need to strife for high quality lesson learned (see Box 8.2). The main part of the user guide provided guidance on how to use the software application to author a lesson learned using annotated screenshots, and instructions explaining what was expected on a content level (see Table 8.2 on page 117 for an overview). It covered the authoring activities RCA2 to RCA6, but not RCA1. RCA7 and RCA8 were implied, but no guidance on these activities was provided. Overall, RCI2 explained the concept of a lesson learned, and how to use the application to document a lesson learned as an *individual* user, but did not describe (self-organized) collaborative efforts for collecting lessons learned (see also Section 8.2.1 on page 112).

Box 8.2: A quality lesson learned (RCI2)

- Includes
  - A clear structure
  - A factual description of the event, a true root cause
  - A specific recommendation
  - Specific Measurable Actionable Relevant Time-bound
- Is not:
  - Only an observation
  - An emotive or subject view or opinion related to an event
  - What results from failure to follow an existing [MarineOrg] standard, procedure or process

8.2.3 Authoring a Lesson Learned

The authoring of a lesson learned was a set of activities (**RCA1** to **RCA8** in Figure 8.1 on page 112) for documenting a single lesson learned together with its context. The activities did not have to be performed sequentially, and authors could interrupt their work and continue later on.

Several of these activities had commonalities in their interaction settings, their use of tools, and deficiency prevention or discovery and fixing. For instance, participants could choose whether to document a lesson learned collaboratively or not (see Section 8.2.1 on page 112). The main tool was a template provided via the lessons learned application. Apart from structuring the authoring activities, the template also provided simple deficiency discovery: clearly marked mandatory fields emphasized that an author had to provide some content for the accompanying prompts. To further prevent deficiencies, RepositoryCol relied on the activities for obtaining information (see Section 8.2.2 on page 113: participants could use the user guide to inform themselves about constraints and quality criteria pertaining to the lessons learned, or to obtain explanations on how to handle the application, which targeted deficiencies due to difficulties in using system, or due to software bugs that were still part of the application.

Task goals, techniques and particular quality assurance mechanisms varied between activities.

RCA1 asked participants to identify lessons learned using semi-structured questioning (with silent answers) as its main technique. The questions (see Box 8.3 for the actual configuration) were prominently placed on the homepage of the lessons learned application. One quality criteria for a lesson learned („specific") and one for actions („SMART-principle") were included in the instructions. The visual cues used in the presentation of the quality criteria emphasized these constraints, and therefore had the potential to prevent deficiencies (see also Kolfschoten et al. (2011) for a similar intervention in facilitated processes).

However, performing RCA1 was optional, which allowed participants to use preconceived ideas for lessons learned without using the techniques and quality assurance mechanisms that were part of RCA1. Also, the lessons learned application did not provide support for collecting a list with the participant's ideas – those had to be collected elsewhere.

Box 8.3: Guiding questions for identifying a lesson learned (RCA1)

1. **Keep doing**: What did we do right?
2. **Stop Doing**: What should we NOT do next time?
3. **Start Doing**: What new things should we do next time?
4. For issues that went **unresolved**: What are preventive measures for next time?

When specifying a lesson learned keep in mind that the description of the event and the lesson learned should be specific. Furthermore, when defining an action apply the SMART-principle: the action should be

Specific **M**easurable **A**ctionable **R**elevant **T**ime-bound

RCA2 was the first activity utilizing the template, and the core activity for documenting or updating a lesson learned and its context. The template could be accessed from the homepage, or through a direct link (for lessons learned that had already been created). This activity also utilized semi-structured questioning as its technique: Table E.2 on page 282 provides an overview of the configuration of the template (consisting of the main prompts and additional questions), supporting tools, as well as additional instructions provided in the user guide. In RepositoryCol, the context of a lesson learned was characterized through past events, the impact on a project, expectations on what should have happened, and a reference to the project, whereas the notion of a lesson learned was limited to a recommendation on how to act in other projects.

Four mechanisms for influencing the quality of the lessons learned could be identified. First, the guiding questions emphasized and explained some of the constraints pertaining to a main prompt, and can therefore be considered a means for deficiency prevention (similar to constraints emphasis in (Kolfschoten et al., 2011)). Second, RCI2 defined quality criteria for the lessons learned. In general, defining quality criteria is a means to prevent deficiencies, if they are kept visible during an activity (Kolfschoten et al., 2011). However, unlike the intervention presented by (Kolfschoten et al., 2011), authors were not asked whether they understood the criteria and agreed with them. Also, RCI2 was an optional activity, making it unreliable for deficiency prevention. Next, using menus as control elements in the template restricted the input in such a way that only existing project names and numbers could be entered. Last, the order of the prompts had an effect on the authors' train of thought: instead of listing all the things that went wrong in a negative lesson learned, authors were encouraged to think about a positive counterpart they expected to happen.

Table 8.2: Documenting and updating a LL (RCA2)

Main Prompt	Additional Question	Additional instructions provided in the user guide	Supporting tools (control elements)
Title*		Be specific	single line of text
Project Name*		Specify the project in which the lesson was learned, there is also the option to indicate that the lesson was related to a tender or to a department.	menu
Project Number*			menu
WBS Element		Do not specify, this is a categorization we might want to use in the future	menu
Expectation*	What was supposed to happen?		text area
Event*	What actually happened?		text area
Root Cause*		Be specific: why did the actual situation differ from the expected situation	text area
Impact	What impact did it have on the project?	What impact did it have on the project/department/tender. Be as specific as possible: delay of x days, budget overrun of x dollars,...	text area
Lesson Learned*		Recommendation (keep doing - stop doing - start doing): the next time this would happen, what would you recommend to do.	text area
Attachments		Insert useful visualizations such as drawings	file dialog

* mandatory field

In **RCA3**, the author was asked to name a person who could verify the content of the lesson learned. The concept of a verifier was not explained further in this activity. However, the user guide (in RCI2) specified that a verifier should assess the content of a lesson learned using predefined criteria (displayed in Section E.4.1 on page 286), correct and extend a lesson learned, and assume co-authorship if necessary. Regarding tool support, the selection of a verifier was enabled by access to an address book (which also served as a quality assurance mechanism) and a text field for entering email addresses.

RCA4 asked authors to assess the importance of a lesson learned using a *multi-criteria rating* technique. In general, a *rating* is an evaluation or assessment of a list of items using a predefined set of criteria (e.g., quality related) with associated scales. Often, criteria imply a direction of preference (e.g., other relevant criteria being equal, lower costs are preferable to higher costs, and higher quality is preferable to lower quality). In contrast to voting techniques, ratings do not imply that choices (relevant for the participant) are based on the rating results – it can also be used to just characterize or classify the rated items. A multi-criteria rating is a rating in which all items are rated on the same set of criteria. For multi-criteria ratings, the configuration may or may not allow participants to skip the rating of some items or some criteria on an item. Also, there are three strategies to rate a list of items (or to choose between them): primarily by criteria (for each criterion do rate all items), primarily by item (for each item do rate on all criteria), or by a mixture of both strategies (based on Lussier and Olshavsky (1979); Payne (1976)).

In RCA4, the multi-criteria rating was performed on only one item (the lesson learned) and consisted of five criteria: the (perceived) probability of reoccurrence, and the potential impact on the cost, schedule, safety, and quality of future projects. The rating scales were five point scales from „very high" to „very low", and included the option „not applicable" (i.e., participants were allowed to skip rating the lesson learned on a criterion), all presented in drop drown lists.

In **RCA5**, authors were asked to manually index the lesson learned. In general, indexing creates a representation of a resource (here: the lesson learned) (Voss, 2007) that can be used for its retrieval (Lee and Schleyer, 2012; Voss, 2007). RCA5 mixed two techniques: an (optional) classification of the lesson learned on multiple dimensions, and (mandatory) tagging. A *classification* consists of a predefined vocabulary with hierarchical relationships (Voss, 2007), constituting classes. Items are then assigned to these classes. In RCA5, lessons learned were classified by core business process (e.g., tender, or execution) and department (including two sub-categories for functional disciplines). Predefined lists of business processes, departments, and disciplines were used to constrain the input options of the author. A classification by project had been part of RCA2, which was used in RCA5 to display an automatic, more detailed, categorization, e.g., regarding the project type and the geographical region. Similar to the classification by project, the main type of tools used for classification were drop down lists.

In contrast to classification, *tagging* allows users to freely choose keywords. Voss (2007); Lee and Schleyer (2012) suggested that users choose keywords they find most appropriate for describing the content. An alternative view suggests that users assign keywords that they consider useful for the retrieval of the content (Cleveland & Cleveland, as cited by (Lee and Schleyer, 2012)). RCA5 did not instruct authors how to choose their keywords, so both alternatives were possible. Tagging was supported by one input field for free text, but the tools did not (yet) suggest keywords already used to tag other lessons learned.

In **RCA6**, the author could suggest one or more actions following from the lesson learned. This activity already prepared for the usage of a lesson learned on an organizational level. During this activity, the author could suggest an action in a single line text field (sic!), specify a task priority (using the drop-down list with options), and a decision maker (similar to identifying a verifier in RCA3).

In **RCA7**, the author had to decide how to continue with the draft. They had four options. Submitting a lesson learned would lead to the next lessons learned process – the verification of the lesson learned. Saving the draft would allow the author to continue with the authoring at a later point in time, or to ask another author to continue working on the lesson learned. Canceling would allow the author to continue immediately with the authoring. Last, authors could also do nothing (leaving the window open in the browser, or closing the browser without saving), which would result in a timeout of the session, and a loss of changes made in the template. The current state of a lesson learned was displayed in a metadata section of the template, that also included a unique identifying number, the creation data, and the author of the lesson learned (**RCA8**).

8.3 Characterizing the Collected Lessons Learned (RepositoryCol)

The set of lessons learned. Overall, 31 LL were documented by the participants. However, 17 of those were entered, modified or extended after a LLCP in DeepwaterProject. 14 (13 negative, 1 other) lessons learned were documented with the LLCP described in this section. In the following, this section further characterizes these 14 lessons learned.

The lessons learned were created during the first four month of the pilot phase (and before the participants were explicitly reminded by the knowledge manager to try out the application) by 3 (sic!) participants. Another 2 participants edited three of these lessons learned.

These lessons learned focused mainly on technical aspects (e.g., relating to equipment for performing measurements), and communication issues (particularly between engineers from the department and subcontractors or other members of a project team). Lessons learned focusing on the product created in the department (i.e., the measurement results, and accompanying calculations) could not be identified.

Structure of the lessons learned. Most lessons learned followed the structure indicated in the template: the fields event, impact, expectation, and root cause provided the motivation and context for the recommendations (outlined in the field „Lessons learned") and the actions. Detailed observations regarding this structure are summarized in Table 8.3 on the next page.

3 lessons learned deviated from this structure. One contained actual undesirable events in the expectations (which should describe what should have happened), another contained positive experiences and instructions on how to achieve these in the impact (not in the recommendations), and the third listed temporal dependencies (and not causal ones) under root causes.

Recommendations and actions. The recommendations were typically kept simple. With one exception (the „other" lesson learned), these recommendations seemed not to have been performed in the originating project.

It is noteworthy that, for preventing events, root causes did not need to be identified in order to develop recommendations. Here, root causes were indeed optional elements of a lesson learned.

Atypically, two recommendations were phrased as a *conditional*. One of these followed the pattern „if not a, then not b", and indirectly suggested alternative courses of action as part of *a*. The other conditional was paired with a main recommendation. The conditional handled a risk that might occur when following the recommendation: it aimed to counteract potential negative effects (increased costs) of the main recommendation.

8.4 Evaluation

RepositoryCol was accompanied by two surveys: one prior to and one after the pilot phase. Data from the first survey provided demographic data about the participants in the pilot phase (see Section 8.4.1.1 on page 121). The second survey explored in which lessons learned activities respondents participated (see Section 8.4.1.2 on the next

Table 8.3: Characterizing lessons learned (RepositoryCol)

LL format used in the LL application	Referring to	Content
Title		Typically referred to the (generalized) events, atypical titles referred to recommendations, impact, root cause, and expectation (1 title each)
Project	Department or originating project	Referred to the originating project, which varied with the LL. One LL referred to a department that would be responsible for using the LL.
Event description: what actually happened?	originating project	One or more states or activities detailing negative or unexpected events in a project. Mainly described problems with equipment and engineering tasks, but also included scheduling and communication between people. Included events that, in MarineOrg, constitute incidents or non-conformances with procedure.
Expectations: what was supposed to happen?	mostly originating project (12 LL), three generalizations	The simplest expectations were negations of the events. Alternatively, expectations elaborated on the negated event (adding details to the event description), or described alternative events originating from the same situation.
Root causes	originating project	Identified 0 to 1 causes for the events. For 3 lessons learned, no exact root causes were identified (including one cause that actually refers to the temporal dependency between events as a causal factor). Otherwise, the root causes provided detailed technical explanations for the observed events or described a lack of desirables that, in the participants' opinion, could have prevented the events if present. The lack of desirables referred to a lack of information, adherence to official responsibilities, or tasks that were not performed or not performed correctly.
Lesson learned	future projects	1 to 2 recommendations for activities to be performed in other or future projects. The recommendations were typically limited to one to two normative statements outlining actions (following the patterns "do X" or "ensure that"). In the negative lessons learned, they aimed to prevent root causes, or to prevent events. If recommendations were associated with causes classified as a lack of desirables, they focused on creating or ensuring these desirables (and only occasionally added more detail). The recommendations associated with technical explanations detailed technical configurations avoiding the causes.
Impact: what impact did it have on the project?	originating project	Either high level impact on projects or lower level impact on work performed by the department. Generally referred to impact on schedule, additional work, and the quality of the work (and deficiency prevention) performed by the department. The "other" lesson learned detailed the a work procedure for recreating a positive experience.
Created by	employee of MarineOrg	3 creators, all of them participants in the pilot phase
Modified by	employee of MarineOrg	3 LL were modified: 2 of them by the verifier, 1 by a co-author

page). Similar to DepartmentCol (see Section 9.4 on page 141), it also asked about the quality of the collected lessons learned. However, as the collected lessons learned in the lessons learned application included both results from the DeepwaterProject and from RepositoryCol, the survey data does not evaluate the outcomes of RepositoryCol on its own, and are therefore not included in this evaluation. For completeness, the results are presented in Section E.4.3 on page 287.

Most lessons learned collected in RepositoryCol underwent an internal verification process (see also Section E.4.1 on page 286 for the criteria used in that process). Results of that peer-verification are presented in Section 8.4.2 on the next page.

After the pilot phase, MarineOrg decided to modify the lessons learned application, and then to introduce it to the whole organization. Section E.4.2 on page 286 outlines (a) what MarineOrg continued to do, and (b) what they decided to change with regard to the authoring of lessons learned.

An interview with the knowledge manager indicated shortcomings in the quality of the collected lessons learned, and their relationship to these changes (see Section 8.4.3 on the next page).

8.4.1 Survey

The two surveys were issued to potential participants of RepositoryCol. The first survey was returned by 11 out of 13 potential respondents (response rate: 85%), the second survey was returned by 8 out of 10 potential respondents (response rate: 80%), with 7 respondents answering both surveys. The difference in potential participants resulted from individuals fluctuations in the department, being on leave, or working offshore[5].

8.4.1.1 Demographics

The respondents to the first survey (10 men and 1 woman) covered an age range from 25 to 59 (see Table 8.4 for more details). 10 respondents stated their role in the organization as senior engineer, lead engineer, specialist engineer (with varying specializations), or a combination thereof; 1 respondent did not indicate his role.

Table 8.4: Age groups (RepositoryCol)

Age Group	Frequency
25 to 29	2
30 to 34	2
35 to 39	2
40 to 44	2
45 to 49	0
50 to 54	1
55 to 59	1

[5]These results were obtained from email responses to the survey invitations, and information obtained from the knowledge manager.

8.4.1.2 Reported usage of application

The reported usage of the application (Table 8.5) shows that RepositoryCol was used to collect lessons learned (with 6 participants submitting, and 4 participants editing a lesson learned). The usage of the application went beyond collecting lessons learned, as it was used to read them, and to support other lessons learned processes (particularly verification and usage).

Table 8.5: RC – Participants' activities during the pilot phase (survey results))

Activity	Number of participants performing the activity	N
Collecting a LL		
Editing a LL	4	8
Submitted a LL	6	8
Participated in LL session	2	8
Not involved in above collection activities	1	8
Examining submitted LL		
Reading (reading or browsing)	8	8
Verifying	3	8
Made a decision on suggested actions	3	8

8.4.2 Internal Verification

Of the 14 lessons learned characterized in Section 8.3 on page 119, 13 had been submitted for verification, and 11 (79% of the characterized lessons learned) were checked by a verifier for correctness, uniqueness, sufficient details, and comprehensibility (see also Section E.4.1 on page 286).

Of these 11 lessons learned, the verifier accepted 10 lessons learned (91%). One lesson learned (9%) was rejected. Of the accepted lessons learned, 2 were accepted only after a first rejection and following revisions made by the author(s).

4 lessons learned suggested actions (29% of the characterized lessons learned), and 2 of those were reviewed. Both reviewed actions were rejected.

8.4.3 Reflections on Authoring Activities

The interview with the knowledge manager revealed several strength and weaknesses of the activities in RepositoryCol, that seemed to have an effect on the quality of the collected lessons learned. More precisely, the interview provided insights into content and structure of the lessons learned, the actions (and the transition towards their implementation), impact estimates, and the conceptualization of lessons learned.

First, the *guiding questions* for documenting a lessons learned and its context (***RCA3***) was considered helpful in creating lessons learned. The distinction between *expectation* and *event* seemed to influence the thought process of the participants: „People really said 'That triggered me to really think what should have happened.' Because otherwise they dive straight into 'oh, this was wrong and that was wrong' and they forget that they do ‘sanity checks”’. Similarly, the *causal analysis* was considered a necessary basis for deriving recommendations.

Consequently, after the pilot phase, the guidance in the template was extended so that every text area in the template (Table 8.2 on page 117) was complemented with a guiding question.

Second, the *titles* (***RCA3***) were sometimes too unspecific, which was attributed to a lack of structure for defining the title.

The assessment of the *importance* of a lesson learned (***RCA5***) was discontinued. Initially, it was considered a means to allow employees in future projects to select lessons learned with the highest impact, but after the pilot, this assessment was considered to be too subjective, as well as unreliable due to changes in the organizational and project environments. Overall, there were concerns about introducing a bias in how lessons learned were selected in future projects.

In contrast, the assessment of the *impact* of a lesson learned on the originating project was extended, asking authors to rate the impact on extant success criteria for projects (i.e., budget, schedule, quality, and safety) using predefined scales.

The documentation of *actions* (***RCA7***) was considered ineffective for fostering change: „If someone is just typing behind his computer, writing a lesson learned, thinking about an action, you’ll never get those bold, big changing actions in there”. Apart from the development of an action through an individual (and not a group[6]), a lack of professional experience was voiced as an additional explanation[7]: „We really see people have difficulty when they sit alone on their computer to think about it. Because it requires a helicopter view, and if you are a junior engineer working on calculations, you often don’t see the bigger picture[8].”

Regarding the relationship between decision makers and actions (***RCA7***), MarineOrg had expected that if the decision maker had sufficient authority, all actions could be covered. However, in practice, they found that actions might be on very different levels (e.g., buying a new ship, and updating a procedure), and therefore each action should have its own decision maker.

Interestingly, the knowledge manager found that actions and lessons learned could form a network: one action could cover multiple lessons learned, requiring a n:m relationship between lessons learned and actions. Also, every action had its own decision maker. In contrast, the piloted lessons learned application only allowed 1:n-relationships between lessons learned and actions.

Last, there was a controversy on whether *incidents* can be reported as lessons learned in MarineOrg. One participant argued that incidents were lessons learned, and documented incidents and non-conformances with existing procedures as lessons learned. The knowledge manager, on the other hand, concluded that a stronger emphasis on the exclusion of incidents reports and non-compliances was needed.

Overall, the knowledge manager considered the quality of lessons learned to be insufficient - particularly in comparison with the lessons learned presented in the next

[6]Potential explanations include: several people can generate more ideas than an individual, and groups take more risks.

[7]MarineOrg also asked verifiers of a lessons learned to add actions if necessary. They found that time pressure on verifiers reduced the number of suggested actions.

[8]These experiences led MarineOrg to develop usage processes that focused on developing actions from lessons learned.

two cases (see Chapter 9 on page 127).

8.5 Discussion and Conclusions (RepositoryCol)

RepositoryCol was unique among the case studies presented in this thesis. It was the only LLCP that did not mandate collaboration. It was also the only process utilizing a lessons learned application as the main instrument to collect lessons learned. As a consequence, the uptake of the process or parts of it was voluntary, and sporadic. Only a minority of the potential participants actually chose to document lessons learned (little uptake of the process).

Even if participants chose to document a lesson learned, they could ignore activities of the LLCP. For other activities, participants might have fulfilled the task goal of an activity using different means than the ones presented in the lessons learned application. For example, they could start the application with an idea for a lesson learned already in mind, ignoring instructions given in RCA1 and RCA3. While this case study showed that only a few participants actually documented lessons learned, further research is needed to understand how (potential) participants engaged in the activities, and modified or adapted them to suit their situation.

While a few participants documented lessons learned using the lessons learned application, the results from the interview with the knowledge manager, the characterization of the lessons learned, and the verification of lessons learned indicated that the quality of the collected lessons learned was mixed. In particular, the participants documented incidents that MarineOrg did not classify as lessons learned. They had difficulties following the structure of the lessons learned, and concluded with weak actions (if any were identified). The evaluation revealed two key weaknesses that may have contributed to these difficulties. First, even though the participants' conceptualization varied considerably, the LLCP did not ensure that participants developed an understanding of what constituted a quality lessons learned in MarineOrg (as all activities for obtaining information were optional). The controversy around incidents indicates that this was indeed an issue in RepositoryCol. Second, participants identifying opportunities for a lesson learned might not have the systemic knowledge to identify „bold actions" that could help MarineOrg in changing its procedures (see also **Part6**). However, the lack of „bold actions" can also be explained with a lack of collaboration in the LLCP: groups can be more prone to take risks than individuals (e.g., Sutter (2009); Bougheas et al. (2013)), and the envisioned „bold actions" may also entail more risks.

Overall, while the LLCP was successful in collecting negative lessons learned, the quality of these lessons learned was mixed: participants had difficulties with the conceptualization of lessons learned, their structure, and the development of actions. Most importantly, the LLCP did not address issues with the uptake of the process.

The slow uptake and the potential variety of ideas on what constitutes a lesson learned suggest that RepositoryCol is an unreliable process for collecting lessons learned when an organization is moving from an informal to more formal LLCP.

Despite these issues, RepositoryCol provided insight into factors related to the abstracted that shaped the resulting lessons learned. Most importantly, participants did not completely ignore the template – most lessons learned actually followed the structure prescribed in the template, and the evaluation indicated that it was used to structure the thought process leading to the lessons learned (e.g., by differentiating between events and expectations). There was also a match between the leading questions in RCA1 and the recommendations developed by the participants: both focused on activities. Only one recommendation deviated from this focus by stating a learning solely in a conditional form.

The template employed in RepositoryCol shaped the structure of the collected lessons learned.

There were also several patterns that could not be explained with the structuring provided by the instruments: the lessons learned were typically negative, even though RCA1 allowed for a broader spectrum of lessons learned, and the LLCP actually asked for positive lessons learned. In addition, the recommendations were typically not performed in the originating project, and constituted (potentially untried) normative behavior preventing the negative events encountered in a project. Thus, the recommendations were focused on prevention, not on reaction to an issue (though one lesson learned provided an example for the latter one). Last, the recommendations did not just focus on what employees of MarineOrg could do differently, but also included recommendations for sub-contractors (who had no access to the lessons learned application).

The abstracted LLCP cannot explain the focus on process knowledge and negative lessons learned, and the inclusion of recommendations for contractors.

Chapter 9

DeepwaterCol Revisited: DepartmentCol

DepartmentCol I & II were two facilitated collaborative LLCPes that did not collect lessons learned from a single project but from a department in MarineOrg. The focus of these cases was on two types of analysis performed in the department (one type of analysis per LLCP).

DepartmentCol I & II were based on the abstracted LLCP encountered in DeepwaterCol I & II. The LLCPes were modified to accommodate some of the instruments for and conceptualizations of lessons learned used in MarineOrg at the time of the pilot phase (RepositoryCol can be considered an overview of these instruments and concepts).

The results presented in this chapter are based on observational notes as well as audio recordings of the process, and are therefore more detailed than those in DepartmentCol I & II, e.g., with regard to interventions of the facilitator. Given this case setup, DepartmentCol I & II allowed the observation of the application of instruments already encountered in DeepwaterCol & RepositoryCol without changing the wider organizational context.

Considering the overlap of the LLCP presented in this chapter with DepartmentCol and RepositoryCol, the following sections focus on presenting similarities, differences, and additional observations to these processes.

9.1 Basic Model (DepartmentCol)

The environment. Both LLCPes shared an environment with RepositoryCol: both abstracted processes were conducted in the same time period in an engineering department in the same organization, and both LLCPes focused on collecting lessons learned independent of a particular project and its milestones. As a consequence, most of the environmental factors outlined in Section 8.1 on page 109 (e.g., relating to the provision of tool support, additional lessons learned processes such as verification and sharing of lessons learned, and MarineOrg's culture) were also relevant for DepartmentCol I & II.

Differences were found in the physical environment. In RepositoryCol, participants could choose where they collected their lessons (requiring only access to the supporting lessons learned application), while, in DepartmentCol the lessons learned were collected in a meeting room in MarineOrg.

Within the department, employees already shared their knowledge orally and in person (showing similarities to the interaction setting used in DepartmentCol I & II). In addition, experiences with the respective analyzes discussed in the LLCPes formed an important part of the environment. For DepartmentCol I, this analysis was a major part of a service offered by MarineOrg. It was perceived as complex and time consuming (e.g., the analysis could take four years for a single project). For DepartmentCol II, the associated analysis was performed frequently. Nevertheless, a routine for the analysis was missing, and tacit knowledge related to the analysis resided with some, but not all, engineers.

Last, one factor relevant for facilitated sessions could be identified as well: the knowledge manager indicated that the organizational environment in MarineOrg was supportive of discussing lessons learned in groups. In particular, observations in other LLCPes indicated that employees were not prone to blame each other for events in a project.

Participants. Overall, 6 engineers (6 men, no woman) participated in DepartmentCol I, and 8 (5 men, 3 women) participated in DepartmentCol II. In addition to the department head, another 3 participants were present in both LLCPes. For DepartmentCol II, one participant from RepositoryCol participated as well.

The interviews indicated a general positive attitude towards lessons learned or knowledge sharing in general.

Similar to RepositoryCol, experiences with lessons learned varied. While one interviewee had read lessons learned from previous projects, another had collected positive or informative lessons learned about how to perform an analysis (which he considered a form of lesson learned). Prior to the LLCPes, the participants had not been introduced to the lessons learned application used in RepositoryCol.

Purpose and task goal. Similar to RepositoryCol, the purpose of the LLCPes were considered on two levels: why collect lessons learned in MarineOrg, and why collect lessons learned within the case boundaries of DepartmentCol I & II. On the first level, the purpose for DepartmentCol did not differ from those in RepositoryCol (see RepositoryCol in Section 8.1 on page 109 for the actual purpose).

On the second level, lessons learned were collected to try out new approaches for collecting lessons learned, to collect lessons learned with more details than in LLCPes performed in projects in MarineOrg, and to assess whether the LLCP would improve the quality of the collected lessons learned.

For both cases, part of the purpose was specific to their respective analysis (see The environment). In DepartmentCol I, the department manager intended the lessons learned to improve efficiency of the analysis, and to solve a predefined problem. In DepartmentCol II, the department manager also expected to elicit tacit knowledge about the analysis, in order to share this knowledge among all engineers who could work on the type of analysis discussed in the LLCP.

The task goal was to collect quality lessons learned (for the respective analysis), and to provide an initial verification of the lessons learned during the LLCP (the latter was not communicated up front to the participants).

Instruments and supporting roles. DepartmentCol I & II were facilitated by the same internal facilitator, who also acted as a writer for the collected lessons learned. The role of the facilitator was taken on by the knowledge manager who helped participants in RepositoryCol.

The main instrument in both cases was an abstracted LLCP based on observations made in the LLCPes in the DeepwaterProject, and modified to include conceptualizations and background information used in RepositoryCol (see Section 9.2 for details).

As a consequence of these modifications, the IT support and tools were a mixture of those used in RepositoryCol and DeepwaterCol I & II. The facilitator used a laptop and the lessons learned application introduced in RepositoryCol to take notes that were not immediately shared with the group, and to store and disseminate the drafted lessons learned. Similar to DeepwaterCol, the facilitator used a whiteboard and pens for documenting contributions that were visible to the whole group, and an audio recorder to record the oral group discussions. In addition, tools were used to support presentations on a screen, and for sending invitations in the form of emails.

9.2 Lessons Learned Collection Processes

This section presents the abstracted and actual processes used in DepartmentCol I & II using the concepts presented in the extended model, and referring back to similar abstracted activities, techniques, or configurations used in RepositoryCol and DeepwaterCol I & II. As DepartmentCol I & II were based on a facilitated approach, concepts relating to repositories only play a minor role in this section.

9.2.1 Preparation Phase

In general, the input categories suggested in Table 5.1 on page 72 could be identified for the LLCPes (see Box 9.1 for the results per input category).

The identified themes, task goal and purpose, the actual participants, as well as some of the prepared instruments varied between DepartmentCol I & II. The reuse of some of the results of the preparation activities indicates that some of these results could have been created as part of designing a department- (or project-) independent abstracted LLCP.

Box 9.1: Input for the main phase in DepartmentCol I & II

Items in italics were specifically created for or adapted to DepartmentCol I or II, and were not found in this configuration in other LLCPes (particularly those in DeepwaterCol I & II, or RepositoryCol). The other items indicate that the input may not have been created specifically for one of both of the cases.

Identified themes Prior to DepartmentCol I & II, two themes relating to the department were identified. Both themes focused on types of analysis that were used in a subset of the projects in MarineOrg and performed in the department.

Goal of the process The task goal and purpose in the LLCPes deviated from the pattern observed in DeepwaterCol: similar to DeepwaterCol I & II, the task goals varied by theme. However, in contrast to DeepwaterCol I & II, the purpose of each LLCP was adapted to the respective theme as well (see also Section 9.1 on page 127).

Designed process DepartmentCol I & II used similar abstracted LLCPes. These LLCPes were based on the design used in the DeepwaterProject, but were adapted, e.g., to fit the sequence of activities to the lessons learned structure used in MarineOrg and the purpose of the LLCPes: in DepartmentCol I & II the gap between expectations and events was not explicitly discussed, reflecting the structure of lessons learned introduced in RepositoryCol; and there was separate activity to discuss positive experiences, reflecting that it was not part of the purpose to celebrate success.

Selected and informed participants The participants were employees of MarineOrg with technical expertise matching the themes for DepartmentCol I & II, and included the department head. The facilitator formally invited them to the LLCPes. One participant per case had to prepare and give a presentation on the theme of the LLCP. Informally, a session owner asked them to prepare topics for the discussion prior to the main phase.

Selected ground rules A selection of ground rules used in both cases is presented in Box 9.2 on the facing page. They set expectations on what to include as a lesson learned, and targeted group norms and values during a LLCP.

Facilitator The same facilitator moderated both observed LLCPes. She was already involved in lessons learned efforts in MarineOrg (see also Section 9.1 on page 127).

Location The LLCPes used a traditional meeting room design (see Justice and Jamieson (2006)) with two areas for presentations, both at the same table head.

Selected and organized tools Similar to DeepwaterCol I & II, the same tools were used in both DepartmentCol I & II (see also Section 9.1 on page 127). Some of these tools were part of the equipment of the room (e.g., a screen and a whiteboard) and therefore did not need to be organized; others were selected or organized by the facilitator (e.g., the lessons learned application and the audio recorders).

Prepared instruments for main phase Similar to DeepwaterCol I & II, the preparation of instruments used some of the outputs from other activities in the preparation phase. Presentations introduced the respective themes (see Section 9.2.2.1), for example. Several instruments from DepartmentCol I were reused in DepartmentCol II (variations could also be found in RepositoryCol): a presentation introducing lessons learned and the LLCP, the specification of a lessons learned format (see Table 8.2 on page 117), and the selected techniques (and most of their configurations) in the main phase did not vary between the two LLCPes.

9.2.2 Main Phase

Similar to DeepwaterCol, the main phases in DepartmentCol I & II were collaborative processes. They took place on two separate days, each lasting about 4 hours.

The abstract LLCP was based on the one in DeepwaterCol. The sequence of activities used in the core phase, and the six interaction settings described in Section 7.2.2.1 on page 92 were also used in DepartmentCol I & II. Several modifications of that abstracted process could be observed. The opening phase was adapted to represent the concept of lessons learned as defined in RepositoryCol. Furthermore, some of the techniques used in the core phase were modified slightly. Last, the closing phase was replaced: instead of collecting positive experiences, the lessons learned application (see also Section 8.2.3 on page 115) was introduced.

9.2.2.1 Opening phase

Using the presentation technique, the facilitator used the opening phase (shown in Figure 9.1 on the next page) to introduce the concept of a lesson learned (as used in MarineOrg), and set expectations on what to expect in the core phase. The presentations themselves were created during the preparation phase, and based on abstractions of the LLCPes observed in DeepwaterCol I & II, as well as information used in RepositoryCol.

Throughout the opening phase, the concept of a lesson learned was introduced and refined. In **DCO2**, the facilitator used a learning loop to introduce the theory underlying lessons learned (particularly how to achieve improvements in projects through direct

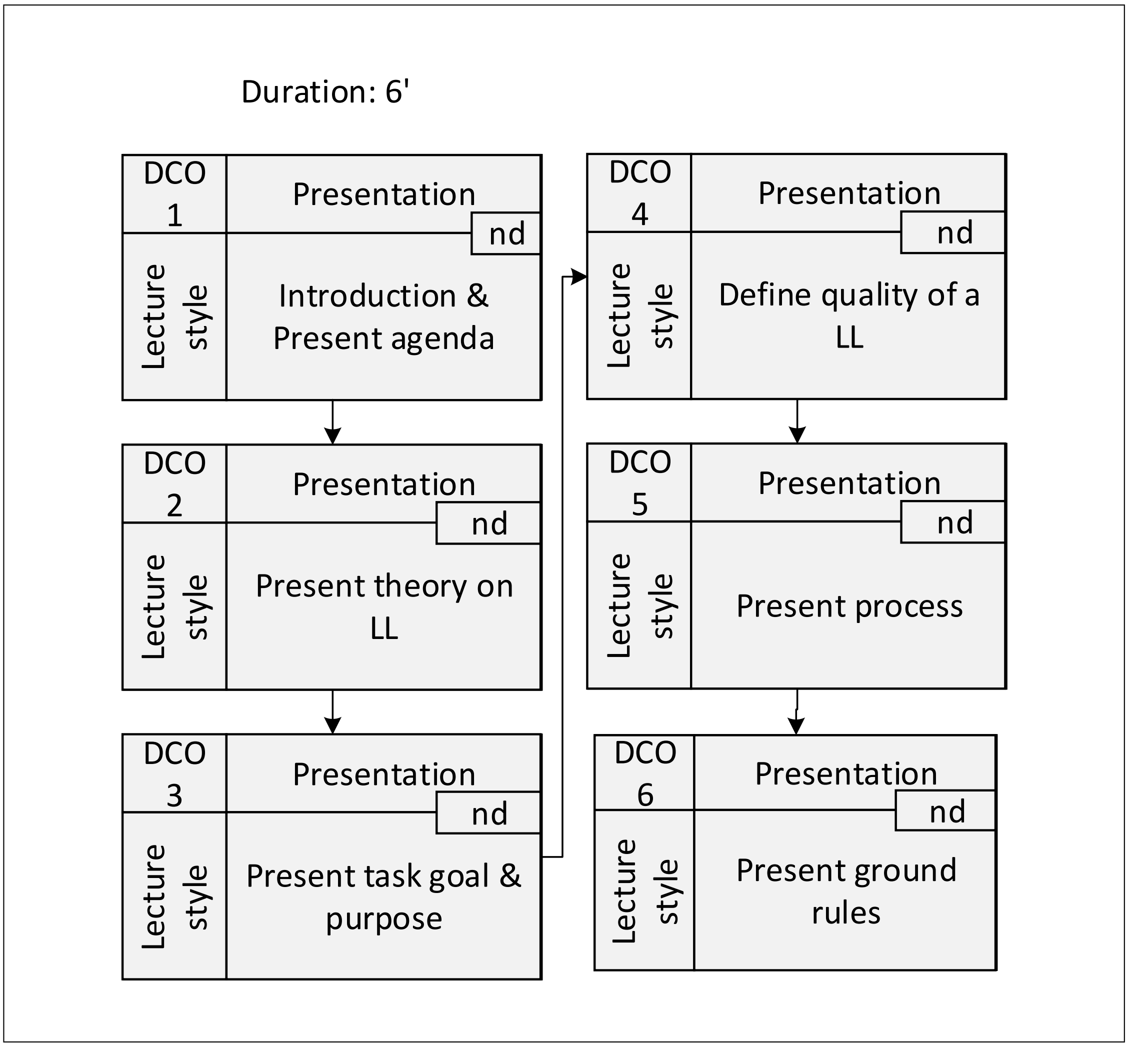

Figure 9.1: Process model for the opening phase of DepartmentCol I & II. Measurements of duration apply only to DepartmentCol II.

actions or application in a project). In **DCO4** and **DCO6**, she addressed quality criteria (see Box 8.2 on page 115) and boundaries (see Box 9.2), and, in **DCO5**, she explained the format of a lesson learned (see Table 8.2 on page 117 for the format; contact information and information regarding the project and WBS elements were not included in DepartmentCol I & II).

Regarding expectations for the core phase, the facilitator introduced an agenda in **DCO1**, informed participants about the specific task goals for the processes (in **DCO3**, see also Section 9.1 on page 127 for the task goals of DepartmentCol), and used the ground rules (in **DCO6**, see Box 9.2) to inform participants about the social behavior for the main phase. Last, the opening phase was also used to familiarize the participants with the recording procedures used during the core phase.

Box 9.2: Ground rules (DepartmentCol I & II)

Expectation Setting: Boundaries for LL

- Both positive *and* negative LL

- Applicable to the future
- Technical *and* softer issues

Group Norms and Values

- Disagreement is healthy
- Be open

Headings and emphasis were added by the researcher.

All in all, the conceptualization of lessons learned, and the boundaries of the concept (both positive and negative lessons learned, addressing both technical and softer issues) were similar to DeepwaterCol I & II. One difference between DeepwaterCol I & II on the one hand, and DepartmentCol I & II on the other hand was that the former limited lessons learned to those based on experiences in the DeepwaterProject, while the latter explicitly allowed different projects. In contrast to DeepwaterCol I & II, DepartmentCol I & II (and also RepositoryCol) presented the participants with quality criteria for lessons learned.

9.2.2.2 Core phase

The abstracted core phases in DeepwaterCol and DepartmentCol were rather similar. In all abstracted processes, the core phase (depicted in Figure 9.2 on the next page) consisted of four sets of activities. For DepartmentCol I & II, the first three sets of activities – introducing the theme, identifying and selecting topics for lessons learned, and collecting lessons learned on the selected topics – were similar to those used in DeepwaterCol I & II. However, the last set of activities from DeepwaterCol I & II was replaced with different activities in DepartmentCol.

Introducing the theme for the core phase At the beginning of the core phase (**DCD1**) the session owner, taking on the role of a presenter, introduced the theme for the workshop using similar tools, techniques, and interaction settings as the ones utilized DeepwaterCol I & II (see Section 7.2.2.3 on page 95). In both cases, the presentation focused on past, present, and future projects or tenders utilizing the theme (a type of analysis). During DepartmentCol I, the presentation included suggestions for topics, and associated them the with purpose of the LLCP.

In order to strive for complete coverage of projects and tenders, the presentation needed to be adapted in DepartmentCol II: the participants noticed that one relevant project was not covered in the presentation, and one participant gave a summary of that project to the group. @discuss{example for QA through participants)

Identifying and selecting topics The identification and selection of topics used an abstract set of activities similar to those presented in for DeepwaterCol I & II. In all four cases, the activity set consisted of three collaborative activities (identify topic, create a list of topics, vote on topics) followed by a supporting activity (analyze voting results). While the basic techniques remained the same, the configurations, deficiency discovery and fixing, were modified. In the following, the similarities and differences for the various activities are presented in more detail.

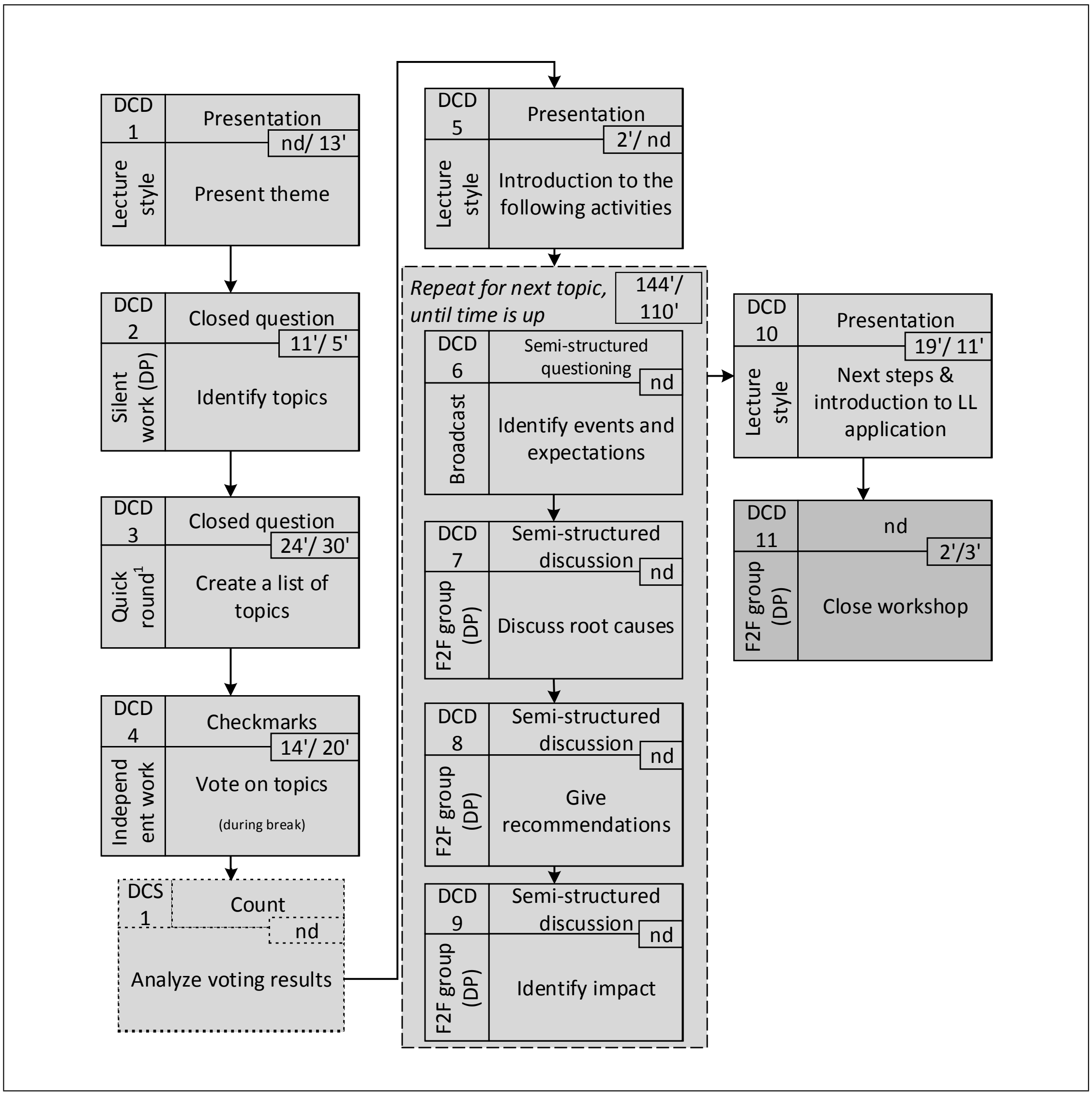

Figure 9.2: Process model for the core phase and closing phase of DepartmentCol I & II. Measurements of duration first state the duration in DepartmentCol I, followed by the duration in DepartmentCol II.

In DepartmentCol I & II, the abstracted task goals remained the same as in DeepwaterCol I & II. Regarding the purpose, two details not noted in DeepwaterCol I & II were communicated. First, the activity set was set in relation to the purpose of the whole LLCP by asking participants to focus on topics that can help to improve the theme in future projects. Second, the facilitator repeated the function (reducing the number of topics to be addressed during the collection of lessons learned) of the activity set.

In **DCD2**, the number of topics per participant was increased from 2 in DeepwaterCol I & II to 4 and 3 in DepartmentCol I & II, respectively. Also, the leading questions in DepartmentCol I & II were more nuanced than identifying „high grade areas to discuss". Overall, a discussion of the topics should help to keep the performance in future projects on the same (already high) level or help to improve it, and fall under the keep doing, stop doing, start doing conceptualization. Furthermore, the topics should fit into the theme of the session. These instructions were based on the general purpose of lessons learned in MarineOrg (see Section 8.1 on page 109) and resembled the instructions used in RepositoryCol (see Box 8.3 on page 116).

In contrast to DeepwaterCol I & II, the facilitator left out the approach to time management, and added deficiency prevention by (orally) emphasizing a constraint already introduced in the opening phase: collecting both positive and negative lessons learned. By stating a target on how many positive topics to include (2 in DepartmentCol I, and 1 in DepartmentCol II), this constraint was easily measurable.

Surprisingly, some participants had prepared written input for this activity, after receiving informal instructions to prepare prior the session. In DepartmentCol I, one participant prepared an extensive list of topics, and another participant had a list of topics handed to him by one of the invited, but non-participating colleague. As a consequence, the facilitator adapted DCD2 by collecting 9 topics from the first participants prior to the next activity in DepartmentCol I. Similarly, in DepartmentCol II, one participant had prepared a presentation with topics to discuss during the session. Here, DCD3 was adapted (see below).

In **DCD3**, the configuration of the technique and its integration with the quick rounds differed between the two cases as well as DeepwaterCol. In DeepwaterCol (I & II), the participants went through two rounds, in which they were asked to present one topic per round. In DepartmentCol I, participants went through a single round in which they were asked to present all their topics at once. In DepartmentCol II, the participant went through three rounds, again with one topic per participant and round. In both DepartmentCol I & II, participants were allowed to contribute all their topics, not just the two most important ones (as in DeepwaterCol I & II).

During the activity, the facilitator did not just note a short title (as in DeepwaterCol), but also used colors to indicate whether a topic was positive (green for something to keep doing) or negative (red for something to stop doing or start doing). Furthermore, during the three quick rounds in DepartmentCol II, participants skipped their turn, or extended topics already listed on the whiteboard. In DepartmentCol I, such skipping or extending could not be observed, as participants were contributing all their topics at once.

To adapt DCD3 to the prepared written input, the facilitator briefly introduced the topics already written on the whiteboard in DepartmentCol I. In DepartmentCol II, she finished DCD3 with a presentation from the participant during which 4 additional topics were recorded on the whiteboard.

Regarding deficiency prevention during DepartmentCol II, the facilitator orally emphasized a few quality criteria: participants were asked to give (only) one sentence as a context, and to not go into details on how things could be improved, or what went well and what went wrong, while referring to recent contributions or discussions as examples for deficiencies (see also constraint re-emphasis in Kolfschoten et al. (2011)).

Deficiency discovery and fixing was performed similarly to DeepwaterCol and relied primarily on input monitoring. More precisely, the facilitator would monitor the input of the participants with respect to specificity (e.g., „who is 'we'?"), completeness of the topic, and categorization as a positive or negative topic. In all instances, the participant contributing a topic was prompted to provide the missing information. Inversely, the participants monitored the notes taken by the facilitator, and could correct any detected discrepancies to their own contributions.

In **DCD4**, DepartmentCol I & II followed DepartmentCol and used the checkmarks technique with the topics as ballot items and five votes for each participants. While DepartmentCol I used a single voting criteria (ability for future improvement), DepartmentCol II combined two criteria (high impact in the past and expected reoccurrence in almost every future project).

Regarding deficiency prevention, the facilitator emphasized these constraints both orally and in writing. Furthermore, in contrast to DeepwaterCol I, and similar to DeepwaterCol II, the participants were not allowed to place multiple votes on a single item (an instruction that was verbally emphasized), potentially preventing participants to up-vote the topics they provided themselves.

Regarding time management, the facilitator prepared the participants for the following activities by explaining that the time needed to discuss a topic could vary considerably between topics, and that some topics could cover multiple lessons learned.

Last, for **DCS1**, no major differences to DPS1 could be observed regarding the technique and interaction setting.

Overall, this activity set resulted in a list with 28 topics (on average 4.7 topics per participant) and 27 topics (on average 3.4 topics per participant) in DepartmentCol I & II, respectively. Both the number of topics and the average number of topics per participant are considerably larger than the results obtained in DeepwaterCol I & II (with an increase of 16 topics in both cases; on average 2 topics per participant in DeepwaterCol I, and 1.6 topics per participant in DeepwaterCol II). The number of votes per topic ranged from 0 to 5 in DepartmentCol I, and from 0 to 6 in DepartmentCol II, which is comparable to the results obtained in DeepwaterCol I & II. All topics were brief, and categorized as positive, negative, or mixed (a categorization that was missing for DeepwaterCol). Similar to DeepwaterCol, the topics were still listed in the order of their contribution. However, only for DepartmentCol II there was a correlation of the order of the first topics with the seating order.

Table 9.1: Number of topics per workshop

	Gathered	Discussed	% of gathered topics
DepartmentCol I	28	9	32
DepartmentCol II	27	10	37

Collecting lessons learned on selected topics (DCD5 to DCD9) The next set of activities (**DCD5** to **DCD9**) focused on collecting lessons learned, and the design of the abstracted activities was based on activities in DeepwaterCol I & II (Section 7.2.2.3 on page 98).

Similarly to DeepwaterCol, the (still visible) topic list was used as a coarse-grained structure, and a lessons learned format was used as a fine-grained structure to guide through the discussions. Also, the interaction settings and techniques observed in DeepwaterCol formed the basis for both DepartmentCol I & II.

Nevertheless, the set of activities differed. For example, DepartmentCol I & II did not identify a contact person (yet), but had an introduction into the collection of a lesson learned (DCD5). This introduction used a presentation technique and matching tools

Table 9.2: Topics discussed in DepartmentCol I & II

DepartmentCol I					DepartmentCol II				
Topic ID[a]	Themes (in discussion)	Positive or negative	# Votes	Duration (min)	Topic ID	Themes (in discussion)	Positive or negative	# Votes	Duration (min)
10	Quality of analysis	+	5	21	15	Purpose of work	-	6	45
4	Standardizing code	-	5	25	24	*Preparation for measuring and analysis*[b]	-	5	2
3	Planning/ Schedule	-	3	37	1	Workflow (measuring and analysis)	-	4	6
7	Working with other departments	+-	3	14	2	*Team for analysis*[b]	+-	3	1
12	Communicating analysis results	-	3	22	6	*Guidelines, checklists*[b]	-	3	together with topic 2
26	*Flexibility of analysis*[b]	+	2	3	9	Data acquisition	-	3	11
1	Training engineers	-	1	12	23	Quality assurance	-	3	11
8	Using / creating regulations	-	1	5	13	*Quality assurance*[b]	-	2	0
19	Analysis during tender	-	1	12	5	Usage of data for decision making	+	2	18
					20	Sharing data	-	0	11

[a] Refers to the ordering of the topics on the flip chart.
[b] Topics in italics were (at least partially) discussed under another topic.

and interaction settings. During this introduction, participants were informed about three major points:

1. the guiding questions used in the following activities and who should contribute to what question. These questions were a sub-set of those used in RepositoryCol (see Table 8.2 on page 117, excluding information the project and WBS, as well as attachments), and are reflected in the activities DCD6 to DCD9.

2. part of the facilitator's behavior (typing notes, creating an audio recording) during the following activities

3. the expectation that the drafts of the lessons learned should be verified by the participants after the workshop

Similar content could be found in the opening phase of DeepwaterCol. Thus, DCD5 moved relevant content from the general introduction to an introduction of a set of activities.

Another difference pertained to the identification of the impact. Even though DepartmentCol I & II clearly identified the impact on a project, this activity was more integrated into the overall semi-structured discussion of a lesson learned. Finally, activities for identifying a gap between events and expectations (part of DPD5 and DPD6) and for identifying a contact person (DPD9). The identification of a contact person was replaced by the general procedure for identifying a verifier, while the omission of an identification of a gap was in line with the guiding questions used in RepositoryCol.

There were also more subtle modifications of the techniques and interaction settings. The selection of topics for further discussion actually used two techniques for selection: for the highest-ranking topics, the topics were selected and discussed in descending order; when faced with a larger number of topics with the same rank, the session owner was asked to choose among these topics. Furthermore, whereas the participant contributing a topic was asked to elaborate on the events and expectations (similar to DPD5 in DeepwaterCol), the other participants were not asked to extend this description but just started with the causal analysis. Thus an equivalent for the discussion of the gap in DPD6 was missing in DepartmentCol I & II. Last, the facilitator did not just categorize the contributions as root causes and recommendations, but also as actions – a concept used in RepositoryCol, but not in DeepwaterCol.

Deficiency prevention, discovery, fixing. Regarding deficiency prevention, no differences to DepartmentCol I & II could be detected. For discovering deficiencies, the facilitator monitored the discussion of the group. Depending on the type of deficiency, various interventions were used to dynamically obtain additional contributions from the participants.

For fixing deficiencies relating to the content of contributions, closed questions were used to reduce ambiguity (e.g., „What do you mean with that? [interpretation 1] or [interpretation 2]?"), to check the understanding of spoken contributions (a typical example would be: „did you say [A] or [B]"), and to improve understandability by making the contributions more specific (e.g., „What do you mean with 'a lot'? Is it like [example 1] or [example 2]?"). Open questions were used to obtain details on suggested recommendations (e.g., „What preparation should people do beforehand?").

In addition, for the first positive topic, the participant contributing events and expectations just noted that they were the same as the topic. In this instance, the facilitator adapted the general question regarding expectations to include topic-specific information in order to obtain more details regarding expectations.

For fixing deficiencies relating to the organization of the contributions, the facilitator obtained confirmations from the participants regarding that organization: whether a topic was positive or negative, and whether a contribution was an action.

Apart from input monitoring, the facilitator asked whether someone wanted to add something in order to obtain a complete list of recommendations or root causes. In addition, the facilitator utilized summaries of, e.g., a single recommendation or all recommendations collected for a topic to provide participants with the opportunity to check whether the summary represented the discussion (correctness), and to check for completeness (in one instance the participant offered additional contributions on his own volition, in some (but not all!) instances the facilitator asked whether anyone wanted to add something). This approach can be considered a comparison. However, in contrast to the comparison outlined in Kolfschoten et al. (2011), the facilitator did not consistently and explicitly refer to a quality criterion.

Content facilitation. The behavior of the facilitator was not limited to providing instructions and intervening in order to detect or correct (potential) deficiencies. Instead, the facilitator (rarely) provided additional information and ideas from her area of work (e.g., on planned changes in data management in MarineOrg), and used her own knowledge in combination with the contributions of the participants to make inferences and to pose questions. Some questions were used to obtain more details on the context of a lesson learned (e.g., „Are you kept up to date on the planning of the project?"), others seemed to be a tentative means to introduce ideas into the discussion (e.g., „[Considering situation X], is it maybe an idea to come up with some form of guidance [..]?").

Similar to DeepwaterCol I & II, this activity set resulted in notes and recordings for each discussed topic, which was used in the post-processing phase to create drafts of the lessons learned (see also Section 9.2.3). Also, the selection of topics for discussion (see Table 9.2 on page 136 for the results) in combination with the time constraints of the core phase reduced of the number of topics, from 28 to 9 (a reduction to 32%), and from 27 to 10 (a reduction to 37%) for DepartmentCol I & II, respectively. These topics encompassed communication issues as well as more technical issues (such as preparation work for measuring). This inclusion of non-technical issues was consistent with the expectations of the facilitator, who had observed similar behavior in LLCPes for projects (e.g., in the DeepwaterProject).

9.2.2.3 Presenting the repository

After collecting the lessons learned, the facilitator briefly presented the lessons learned application (see Chapter 8 on page 109) in **DCD10**. In effect, the facilitator created an orientation for the participants on how they could use this application after the workshop. During DCD10, she demonstrated of the software that included functionality for documenting lessons learned (see Section 8.2.3 on page 115 in RepositoryCol), task lists relating to drafted lessons learned as well as verification, and options for accessing lessons learned. In addition, she justified limitations such as a slow performance with the pilot state of the application.

In DepartmentCol I (and to a limited extend in DepartmentCol II), she linked this demonstration to two steps in the post-processing phase: her task of organizing and extending the notes, and the participants' task of verifying the drafted lessons learned.

9.2.2.4 Closing phase

During the closing phase (**DCD11**), the facilitator thanked the participants, summarized the post-processing activities (see Section 9.2.3 for details), and answered last questions posed by the participants. The summary of next steps focused on the type of activities in the post-processing phase and general responsibilities. Details on these post-processing activities (e.g., which participant should verify which lesson learned till when) were not discussed.

9.2.3 Post-processing Phase

The post-processing phase (as discussed during the main and closing phase of the workshops) consisted of four activities.

1. The facilitator intended to organize and extend the notes taken during the workshops. Organizing the notes should include structuring the contributions using the lessons learned format, and split topics into several lessons learned if necessary.

2. The facilitator intended to notify the participants via email on who should verify which lesson learned. The email was expected to contain a link to the lessons learned application, as well as more detailed instructions on how to verify the lessons learned.

3. The facilitator intended to provide the session owners with a list of those topics that were not covered during the main phase.

4. Following point 2, the participants were expected to verify, extend, and correct the drafts of the lessons learned. In addition, they were to name a person for a second verification of the lessons learned.

During the last activity the participant's name was associated with the lessons learned, in order to allow users to contact this participant, and obtain in-depth information on the lesson learned. Nevertheless, to prepare for situations where the participant would no longer be available, the lessons learned was expected to be documented well.

With the exception of the third activity, the exported lessons learned contained evidence that these activities had actually been performed (though not consistently for all lessons learned): lessons learned were split up after the workshops, participants were listed as verifiers for lessons learned, and some lessons learned were moved from a draft to a submitted status.

9.3 Characterizing the Collected Lessons Learned (DepartmentCol)

The set of lessons learned. Overall, DepartmentCol I & II resulted in 12 (1 positive, 9 negative, 2 other) and 13 lessons learned (1 positive, 10 negative, 2 other), respectively.

There are two things to note about the separation into positive and negative lessons learned. First, two lessons learned in DepartmentCol I indicated a *mixture of positive and negative experiences* (the 'other' lesson learned). The first of these lessons learned stated in the event that the situation in the department was generally good, and then continued to describe areas for improvement (resulting in a „good, but" description under events), followed by an entirely negative impact (sic!), and suggestions for improvement (not for what to keep doing). Overall, this lesson learned starts with positive experiences, but then focuses on the negative aspects. The second one described both positive and negative consequences of the events, and recommended continuing with (an improved version of) the events („keep doing") or aiming for an alternative situation altogether („start doing").

Second, some lessons learned on inconsistent past results could also be considered as infrequent positive experiences that participants wanted to repeat more consistently. One example for inconsistent results pertained to observations that some (but not all) engineers would perform a part of the analysis earlier than others, which was considered desirable. In supporting an earlier analysis, the participants identified a key factor (experience of the engineer) as a cause, and recommend the development and use of artifacts (e.g., checklists) to support engineers with less experience in an earlier analysis. Even though such lessons learned were phrased as negative lessons learned, they were based on a mixture of positive and negative experiences. It is the *framing of the underlying events or situations* that resulted in a typical storyline for a negative lesson learned - not the events or situations themselves.

The set of lessons learned contained both lessons learned focusing on the process, and lessons learned discussing the products offered by the department. More precisely, in DepartmentCol I & II, the lessons learned focused on technical aspects of the analysis (e.g., how to organize code, how to develop a standard for the analysis, or how to improve quality of data collected by sensors), as well as softer issues the engineers encounter (e.g., how to communicate results of the analysis, or how to deal with a lack of experienced engineers). The actual product (the analysis results, or their dependency on input variables) was not addressed in DepartmentCol I. In contrast, lessons learned resulting from DepartmentCol II also contained recommendations on how to use the analysis as a service to create value during the projects.

Structure of the lessons learned. All except one lesson learned followed the structure outlined in the opening phase (see Section 9.2.2.1 on page 130). With the exception of the differences between events and expectations, this structure was similar to the one found in Section 7.3 on page 103. Detailed observations regarding this structure are summarized in Table 9.3 on page 142 – with the exception of the categorization of the lessons learned.

Split topics. Split topics could be traced to the lessons learned. In DepartmentCol II, lessons learned discussed under the same topic actually described different events, causes, and recommendations. In contrast, in DepartmentCol I, the resulting lessons learned partially or completely shared their descriptions of the context (topics, the events, expectations, and impact), but contained different clusters of root causes and, consequently, recommendations.

Recommendations and actions. The recommendations and actions of DepartmentCol I & II had some noteworthy features. First, the recommendations could indicate that, while a situation can be improved, the *expectations might not be entirely satisfiable* (particularly when dependent upon other stakeholders associated with a project). Second, the recommendations and actions could indicate *several alternative courses of actions* (including preferences for one of these alternatives). The choice between these alternatives seemed to be depended on other stakeholders (in the project, organization, or industry). Furthermore, the recommendations aimed to *directly improve future projects or to indirectly improve the current situation in the department.*

In addition, it is noteworthy that *neither the recommendations nor the actions had been (consistently) followed in past projects*. This holds even for the positive lessons learned. For the positive lesson learned in DepartmentCol I, the root causes listed high-level causes contributing to the positive experiences (things to repeat), the two recommendations focused on (a) improving upon the already good situation, and (b) replacing the influence a client had exerted in the past with an influence internal to the department. Similarly, the positive lesson learned in DepartmentCol II contained recommendations on making the analysis easier, more frequent, and powerful (by dealing with a negative lesson learned).

Last, recommendations focusing on what to do in future projects could still be *dependent upon actions*: one recommendation was to follow an internal standard for the analysis (with details on what the standard should entail), while the action focused on actually creating this standard. In DepartmentCol II, the recommendations from one lesson learned could also reference other lessons learned, and require them to be applied, leading to a *dependency between lessons learned*.

9.4 Evaluation

Similar to RepositoryCol, DepartmentCol I & II were accompanied by two surveys (see Section 9.4.1): one prior to and one after the pilot phase. The demographic data from the first survey is presented in Section 9.4.1.1. The second survey was used to assess the perceived quality of the collected lessons learned (see Section 9.4.1.3). It also explored the activities respondents participated in, indicating the foundation for these assessments (see Section 9.4.1.2).

Some lessons learned collected in DepartmentCol I & II underwent an internal verification process (see also Section E.4.1 on page 286 for the criteria used in that process). Results of that peer-verification are presented in Section 9.4.2 on page 143.

Last, an interview with a knowledge manager was used to create insights into the quality of the collected lessons learned (see Section 9.4.3 on page 144).

9.4.1 Survey

9.4.1.1 Demographics

The respondents to the first survey (13 men, 2 unknown) covered an age range from 26 to 48 (see Table 9.4 on page 143 for more details). 12 respondents stated their role in the organization as engineer, specialist engineer or marine engineer; 1 respondent as advisor.

9.4.1.2 Reported activities

The reported activities (Table 9.5 on page 143) indicate that the majority of respondents (78%) assessing the quality of the collected lessons learned were also involved in their collection. Similar to RepositoryCol, the exposure to lessons learned went beyond a LLCP and included reading lessons learned, as well as the involvement in other lessons learned processes (particularly verification and usage).

9.4.1.3 Perception of the collected lessons learned

The respondents' assessment of the process output is displayed in Table 9.6 on page 143.

The responses indicated a weak positive perception of the quality of the lessons learned (both in the full scale, and on the reduced scale used in InnovCol). Importantly, the lessons learned were considered practicable, and contained sufficient context. The responses also indicated that the lessons learned were not (yet) part of an integrated knowledge portal.

Table 9.3: Characterizing drafted lessons learned (DepartmentCol)

LL format[a]	Referring to	Content
Title		Theme of the LLCP (the specific analysis), followed by the (modified) topic a title for the recommendation or main event.
Event: what did happen	(current) department, organization, or industry (b) past project(s)	Referred to situations/ states (sic!) or to events. Negative LL described a situation or events to avoid, positive LL described a situation to maintain. One of the mixed LL outlined a positive situation with room for improvement.
Expectations: what should have happened?	generalization [b] of project industry the department	For one positive LL: past expectations that were exceeded. For negative LL: desired state or event(s) that (in simple LL) were an inverse of the event. Expectations could add details to the events (e.g., the events indicated that more communication with other departments is needed, and the expectations added what is needed from these department), or could outline alternative expectations.
Impact	past project(s) or generalization of projects	Effects on a project (including initiation or preparation of the project). Several impact descriptions were phrased or implied as conditionals (e.g., <events> can lead to <impact>). The effects could be internal (e.g., effectiveness, quality, and efficiency of analysis, quality of data, work-related stress, additional work required) or external (e.g., impact on reputation of MarineOrg regarding the analysis, or perception of client) to the work performed by the participants.
Root causes	past project(s) or (current) department / organization	A list of (not necessarily independent) factors used to explain the events. For negative LL, some of these factors were phrased as a lack of something (e.g., a lack of trust). In DepartmentCol I, causes included the low number of projects in which the analysis was used, characteristics of the analysis (and consequences thereof), other stakeholders' (misguided) perception of the analysis or the engineers, communication issues, and knowledge management or human resource issues (e.g., lack of internal or external standards or guidelines, lack of senior engineers).
Lesson learned: what did we learn	future projects or department	List of recommendations. These lists contained items that had not been followed in the originating project or in the department, and that prevented a cause, reduced negative consequences of the root causes (e.g., through a mitigation strategy[c] or indicated that some things needed to be accepted. The LL contained recommendations detailing (a) behavior and attitudes for engineers of the department, (b) ideas for artefacts/ knowledge objects and how to use or develop them (e.g., the idea to develop predefined text for tender bits), and (c) recommendations for future projects (also requiring the cooperation of project managers or project engineers). Several LL acknowledged limits regarding the engineers' influence and included alternative recommendations (e.g., a preferred option, and one to take if the preferred one is not possible).
Action	department	List of activities/ first steps that the department needed to take for the LL to be usable during a project. They included the development of artefacts required to apply a LL (e.g., a LL recommended using a standard, while the action focused on developing this standard), creating awareness about the analysis in project teams, and further investigations needed to move towards a solution.
Created by	employee of MarineOrg	Main creator: writer One exception: participant
Modified by	employee of MarineOrg	Either the writer, or a participant in the LLCP who took on the role of the verifier

[a] as introduced in the opening phase

[b] projects using the type of analysis discussed during the workshop

[c] A mitigation strategy is a notion found in risk management aiming to reduce the likelihood or severity of consequences of a risk, see Hillson and Simon (2007))

Table 9.4: Age groups (DepartmentCol)

Age Group	Frequency
25 to 29	4
30 to 34	3
35 to 39	2
40 to 44	0
45 to 49	2

Table 9.5: Participants' activities during the pilot phase (survey results))

Activity	No of participants performing the activity	N
Documenting a LL		
Editing a LL	4	9
Submitted a LL	6	9
Participated in LL session	7	9
Not involved in above collection activities	2	9
Examining submitted LL		
Reading (reading or browsing)	8	9
Verifying	4	8
Made a decision on suggested actions	3	8

9.4.2 Internal Verification

Of the 12 lessons learned collected in DepartmentCol I, all had been submitted for verification, and 7 (58%) were checked by a verifier using the criteria outlined in Section E.4.1 on page 286. Of these, the verifiers had accepted all lessons learned. 4 (57% out of these 7) lessons learned suggested actions, and 2 of those were already reviewed (using Box E.2 on page 286). Both reviewed actions were accepted.

For DepartmentCol II, only 2 out of 11 lessons learned (18%) were submitted for verification. Both lessons learned were accepted. One of these 2 lessons learned suggested actions, but was not reviewed yet.

Table 9.6: Perceived quality of LL (DepartmentCol)

	N	Median	Q1	Q2
Content quality of LL (8 items)	8	4.5	3.3	5.4
Content quality of LL (reduced scale, 6 items)	7	4.8	2.8	5.2
Items				
The LL in the piloted system are practicable.	9	5	4	6
The LL provide sufficient context so that I can easily understand it and apply it to my work	8	5	3.3	5
The piloted LL system provides a complete knowledge portal so that I can link to knowledge or information sources for more detailed inquiries	6	3	2	5

9.4.3 Interview with the Knowledge Manager

Usage of LL. Similar to DeepwaterCol, the lessons learned were not used on an organizational level. This lack of usage was attributed to two causes. First, the person interested in the lessons learned (the Department head) left for another position. Second, „in the past [managers/employees] could get away without doing anything". Also, due to the nature of the LLCP as a pilot, they were not required to actually follow up on the actions.

Perceived quality of lessons learned. Overall, the LLCP seem to result in a higher quality of lessons learned than RepositoryCol. The interviewee attributed this to 3 causes. First, these collaborative LLCPes involved different participants with wearing perspectives on the themes. Second, the discussions around lessons learned (DCD5 to DCD9) seem to challenge the participants' opinions („you've got one person's opinion and another person's opinion, and the truth is normally somewhere in between there"), allowing participants find positions acceptable to the group and leading to better recommendations. Last, during the LLCP, participants automatically perform part of the verification as they monitor and react to each other's contributions.

Continued usage of instruments. Several instruments encountered in DepartmentCol were continued to be used in MarineOrg, indicating that these instruments had value for the organization.

First, the abstracted LLCP was listed as one lesson learned process for collecting lessons learned. The interaction settings in the process could be exchanged for one better suited to handle large groups (this interaction setting will be introduced in TerminationCol, see Section 11.2.2.1 on page 180). Planned changes included a separation of the facilitator's role from that of the one documenting a lesson learned during the LLCP, in order to reduce the considerable workload of the facilitator during the LLCP. Also, MarineOrg considered training engineers as facilitators, in order to scale up the usage of the LLCPes.

Second, lessons learned were assigned contact persons for verification and for providing contact information and networking opportunities (it was considered easier to use lessons learned to identify the right person to talk to than to work only with the documented lesson learned; but the documented version took into account that the contact person might have already left MarineOrg).

Furthermore, lessons learned collected in a facilitated LLCP were continued to be stored in the application introduced in RepositoryCol, even if the will was not used to actually collect a lesson learned: „I still see it as a possible scenario that in 5 years we capture all lessons learned through sessions, and we use the [template] to capture what was discussed."

Last, there was no option allowing participants to decide to make a lesson learned confidential (i.e., the lesson learned would only have been accessible to the participants of the LLCP, but not to other employees of MarineOrg), even though participants (particularly from the DeepwaterProject) objected to the publication of the lessons learned. Instead, participants had to convince a gatekeeper to make a lesson learned confidential.

9.5 Discussion and Conclusions (DepartmentCol)

The case studies DepartmentCol I & II were based on the abstracted process described in Chapter 7 on page 89. Both cases followed this abstracted processes, but contained some deviations. These deviations included a focus on collecting lessons learned from a department instead of a project, marking a topic as positive or negative in DCD3, and adaptations to the organizational lessons learned effort in MarineOrg (resulting in a modification of the question structure used in DCD6).

The characterization of the collected lessons learned (see Section 9.3 on page 139) indicates that the process can be considered a success: during the LLCPes well-structured, extensively documentedlessons learned were collected (though some lessons learned did not comply with the structure, or were incomplete). These lessons learned documented positive and negative experiences (as events and impact), attributed these experiences to root causes, and outlined what to do in order to repeat positive experiences or prevent negative experiences from reoccurring. Thus, both the how and why aspects of process knowledge were addressed, and the main task goal was achieved.

Nevertheless, the challenge to collect positive lessons learned was inadequately met: only two lessons learned (one per case) were clearly based on positive experiences. The analysis of the structure of lessons learned in Section 9.3 on page 139 also indicated that, for some lessons learned, there is a choice whether these lessons learned are framed as positive or negative. More precisely, lessons learned could be based on a mixture of positive and negative experiences that led to inconsistent results across projects. These lessons learned recommended additional measures to be taken in order to obtain more consistent results. They were framed as negative experiences, even though a logically equivalent positive version would have been conceivable.

Regarding potential usage scenarios, the ***usability*** of these lessons learned in future projects was limited. Most lessons learned contained recommendations for *prevention* instead of reaction, and needed to be used either on a departmental level, or *early on* in a project. Also, actions accompanying a lesson learned outlined additional steps required for recommendations to be practicable. These actions all needed to be taken on an organizational level, and could entail considerable effort. This might make a lesson learned useless, if it is only considered at the beginning of a project (though expert evaluations are missing to confirm this risk). This also indicates that neither the recommendations nor the actions had been consistently followed in past projects, but represent untried solutions to the problems outlined in the lessons learned.

Overall, the LLCPes were successful in collecting process knowledge, and (potentially untried) recommendations aiming to improve future projects. However, the set of collected lessons learned seemed not to cover all usage scenarios, and was still biased towards negative lessons learned.

As such, with the exception of the dependency on actions for using lessons learned during a project, the success in collecting lessons learned can be considered similar to DeepwaterCol I & II, even though the task goal changed from collecting lessons learned from a project to collecting lessons learned in a department.

Similar to DeepwaterCol I & II, no major discrepancies between task goals for activities and their intermediary outcomes could be observed. Thus, the abstracted process can account for observed intermediary and final outcomes such as a list of topics, and the reduced list that was discussed during the workshop.

However, the chosen research methods did not allow to investigate outcomes related to internal states of participants (e.g., whether participants changed their understanding of what constitutes a lesson learned, or whether the ground rules resulted in a change of expectations as an effect of the opening phase, see also Section 6.2.3 on page 86). Three instruments ostentatiously influenced characteristics of the set of collected lessons learned. First, the questioning structure used in DCD6 to DCD9 was formally reflected in the structure of the resulting lessons learned (though deviations and additions could be found, see below). Second, the theme selection (as part of the preparation activities, see Section 9.2.1 on page 129) and (third) the topic identification and selection (in DCD3 & DCD4, in conjunction with the actual selection during the discussion) actually limited which topics were discussed (i.e., there were topics that were not covered in the discussions), and may have reduced the quantity of discussed topics (i.e., participants did not rush through the complete list in an attempt to address each topic, but took their time on the selected topics).

A more subtle influence was exerted through quality assurance enacted during the discussions. The interventions had the potential to improve the level of detail for lessons learned, and improve the understandability of lessons learned (e.g., by removing ambiguity, or categorizing contributions as actions).

Overall, the abstracted LLCP shaped key characteristics (quantity, topics, structure, understandability and level of detail) of the collected lessons learned.

Similar to DeepwaterCol I & II, it should be noted that it was not the presence of instruments that resulted in these patterns. Rather, their effects were mediated by the guidance and restrictiveness imposed by the facilitator (though an assessment of the extent to which participants followed the guidance and complied with the restrictions was limited due to the research methods).

Guidance and restrictiveness provided by the facilitator and written instructions may have mediated the effects of the abstracted LLCP.

Similar to DepartmentCol I & II, the drafted lessons learned showed unique characteristics that could not be attributed to the instruments used during the LLCP.

First, the lessons learned did not just describe events but also situations in the field (here, situations are states while events are about something happening). Thus, when collecting lessons learned from a department, improving upon or maintaining a ***situation*** was perceived as helpful for achieving the purpose of the LLCP. Considering that the lessons learned were collected in a department, and assuming that, without any further actions, situations could persist and still exist in the next project, lessons learned focusing on improving upon a situation can actually have an impact during a project. For example, a situation might be a lack of engineers with extensive experience in a step of the work procedure. Improving upon this situation through knowledge management interventions (e.g., training, networking approaches, or explicating and using know-how in the form of checklists) was discussed for improving the performance of inexperienced engineers during a project.

Second, while the question structure suggested that there should be a relationship between ***recommendations*** on the one hand, and causes, events, and expectations on the other hand, this relationship was not further specified. The drafted lessons learned showed that recommendations could contain suggestions[1] for

1. preventing causes
2. disrupting the connection between causes, and events /situations
3. fulfilling the expectations without obvious connections to either events /situations or root cause

Furthermore, the recommendations were written from an ***in-group perspective*** – they focused on the engineers in the department by recommending how these engineers should act in their organizational or project environment, or situations in which the engineers would like to find themselves (e.g., having senior engineers for certain tasks instead of junior engineers, without specifying who makes the decision on this). Other stakeholders played little or no role in these recommendations. Nevertheless, the lessons learned could take into account the whole organization („how would MarineOrg - as a system - be better off?") by suggesting how the engineers could contribute to that.

Exceptions to this in-group perspective exist, though: these recommendations (or actions) explicitly asked for a ***collaboration with other stakeholders*** such as the tender department, institutions documenting standards, or industry partners, and required joint action for the lesson learned to be effective.

The collaboration with other stakeholders introduces an element of ***uncertainty***, as representatives of these stakeholders were not among the participants. In general, constraints for the analyzes discussed in the two cases (time available for performing the analysis, how many engineers are employed on a project) can depend on project management and other internal and external stakeholders.

For events and situations depending on such constraints, participants would not have the influence to choose which recommendation to implement in future projects. The lessons learned explicitly dealt with uncertainties by pointing out several recommendations, e.g., a preferred one and one if the preferred one is not possible. The latter could also be presented as a mitigation strategy helping the engineers to cope with undesirable causes.

Some lessons learned were based on complex ***networks of interdependent events and states***, which were split up into separate lessons learned. Some of these interdependencies became obvious as the lessons learned were discussed under the same topic, others emerged during the discussion as references to already discussed recommendations. The set of lessons learned indicated two ways to deal with these interdependencies. First, events, expectations, or the impact were a (partial) copy of the descriptions in dependent lessons learned, with different clusters of root causes and recommendations (the clustering criteria could not be identified in this research). Alternatively, the recommendations could be dependent upon each other, leading to cross-references between those.

Last, this includes patterns influencing the usability of the lessons learned: namely a focus on ***preventative measures***, and the dependency between recommendations and actions (and the accompanying effort required to make a lesson learned useful). The latter also includes ***postponing*** extensive activities to a later point in time. For example,

[1] Please note that this listing is tentative, as no categorization by experts could be performed.

actions could ask for the development of a (complete) checklist, while the lesson learned (and the discussion) listing starting points for that checklist. Explanations for postponement include time constraints (creating a complete checklist for the example above would require additional knowledge explication, and therefore time), as well as dependencies on other stakeholders not represented among the participants.

The abstracted LLCP cannot explain these patterns for developing recommendations and actions, the focus on negative lessons learned, and how complex networks of interdependent events were separated into lessons learned.

Chapter 10

RefineryCol[1]

RefineryCol was the only case in this thesis using a LLCP designed by the researcher. It was also the only case taking place in an organization that routinely collected lessons learned using formalized procedures.

This project involved multiple stakeholders, among others a client organization and a contractor handling the management and engineering part of the project. The project team regarded the project as not successful in terms of budget and schedule. Several team members stated that at least one of the project managers played a major role in that situation.

Thus, RefineryCol presented an opportunity to explore how to collect lessons learned when there were major conflicts between stakeholders or individuals involved in the LLCP.

10.1 Basic Model (RefineryCol)

Environment. The lessons learned in this project were collected in retrospect after the execution phase of the project. The physical environment for the various activities in the LLCP varied, and included meeting rooms at OwnerOrg and the contractor's office building, as well as in the university. With one exception, they were either conducted in a meeting room located in the participant's organization (representing familiar ground) or in the university (representing neutral ground). As the exception, the program manager from OwnerOrg was interviewed in a contractor's office building.

Events in the RefineryProject influenced both in the design of the LLCP and the content of the lessons learned. Among these events were conflicts within the project team that extended along the line of OwnerOrg versus the main contractor (see also Box 10.1 on page 153). The introduction of the LLCP was also influenced by personal experiences of the interviewer with lessons learned sessions in OwnerOrg, as these experiences were used to explain the approach taken to collect lessons learned in RefineryCol (see Box 10.2 on page 154 for details).

The participants' experiences in RefineryProject formed the foundation for the lessons learned: throughout the LLCPes, participants in various roles referred to events and situations in the project, the structure of the project, as well as the environment of

[1] An earlier version of this process has been published in Buttler and Lukosch (2012).

the project (e.g., regarding government regulations for the project site influencing the purpose of the project).

Further identifiable influences of the environment on the LLCP include the intention to collect lessons learned: collecting lessons learned was mandatory in the organization at that time, and therefore, it was not an option to not collect lessons learned.

Participants. 8 individuals (all men) were invited to participate in the LLCP. Of those, 7 agreed to participate. Overall, 7 men participating in the LLCP (see Table 10.1 on the next page for an overview). The participants included project managers, their managers, as well as individuals working on the project, and were associated with either OwnerOrg or the contracting organization. At the time of the interviews, A7 was no longer employed by OwnerOrg, but nevertheless agreed to participate in the LLCP. He had left the project during the construction phase, and one of the other participants (A6) replaced him in the project. With the exception of these two participants, the participants were involved in most of the project. The individual who did not participate was a representative of the project site (operations), and would have added a user's perspective on the product created in the project.

Six participants had prior experience with LLCPes (no data for one participant), 5 of them also with LLCPes performed in OwnerOrg.

Purpose and task goal. The main purpose of the LLCP was rooted in the insight that the way the project was performed needed improvement. Therefore, the typical purpose of LLCPes in this thesis of preventing the repetition of mistakes and of repeating successes applied. In addition, RefineryCol was associated with a research purpose: suggesting alternatives for collecting, storing and retrieving, and using lessons learned.

The main task goal was to collect lessons learned about project management and execution and to produce a written report as well as a spreadsheet with the resulting lessons learned. In alignment with the proposed research, the task goal was extended with suggesting alternative approaches for the collection, storage and retrieval of lessons learned. The design of the LLCP was additionally influenced by the potential opportunity of using some of the stories as training material for future project managers in OwnerOrg.

Instruments and supporting roles. The most important instrument for RefineryCol was an abstracted LLCP (introduced in the following sections). Observable tools included pen and paper for taking notes. The ICT support included screens and laptops, and presentation software. In addition, recording equipment was used to record the interviews and the oral discussions during the workshop. For the workshop phase, a GSS was used as well.

RefineryCol was supported by an external, independent team of researchers. They acted as interviewers, facilitator, analysts (somebody analyzing interview materials, and condensing them to lessons learned), and writers.

10.2 Lessons Learned Collection Process

In contrast to the other cases on collaborative LLCPes, RefineryCol did not follow the structure outlined in Section 5.3.1 on page 71. Instead, the main phase could be further divided into three separate phases: the interviewing phase with a series of interviews with the participants, an intermediary phase for analyzing the interviews and preparing the next phase, and a workshop phase for further discussion and refinement of the lessons

Table 10.1: Participant characteristics and their perception of success (as stated in activity RPID2). Participants are listed in the order in which the interviews took place.

Interviewee	A1	A2	A3	A4	A5	A6	A7
Position	Construction manager	Various (including process engineer)	Manager projects	Project manager	Portfolio program manager	Project manager	Project manager
Affiliation	Contractor	OwnerOrg	Contractor	Contractor	OwnerOrg	OwnerOrg	OwnerOrg
Perception of success					(not discussed)		(not discussed)
Goal achieved/ product delivered	-	yes (product delivered)	-	no (late delivery threatened license to operate)	-	yes (key stakeholder was happy)	-
Process *- in general*	-	no	yes	-	-	-	-
Safety	yes	-	yes	-	-	-	-
Cost	no	-	no	-	-	-	-
Schedule/ Planning	no	-	no	-	-	-	-
Quality	mixed	-	yes	-	-	yes	-
Relationship with OwnerOrg	mixed (successful with direct contact, but not with A7)	-	no (no continuation of business with OwnerOrg)	-	-		-
Relationship with other contractors	mixed (one contractor stands out in terms of negative relationships)	-	-	-	-	-	-

learned.

In the following, this chapter first presents the shared preparation phase for the whole process, followed by the interaction settings, the three phases outlined above, and an overall post-processing phase.

10.2.1 Preparation Phase

This section presents results for the general preparation of the LLCP (particularly the goal of the process, and general design considerations), and preparations for the interviewing phase. Preparation activities for the workshop phase are presented in Section 10.2.4 on page 163.

In general, the potential input categories suggested in Table 5.1 on page 72 could be identified for RefineryCol. Box 10.1 on the next page presents findings on decision criteria and design rationales for these activities, as well as their outcomes.

RefineryCol is the only case included in this thesis for which a design approach rooted in literature was available. The LLCP focused on addressing three concerns (Buttler and Lukosch, 2012):

1. allowing to collect negative lessons learned (see also challenge **Out4** on page 61 and challenge **Part3** on page 63): considering the mixed perception of success of the project, the existing conflicts between stakeholders, and the role of the project managers (A4 and A7), the ability and willingness to learn from things that did not go well was a major concern in RefineryCol
2. collecting process knowledge (see Box 3.3 on page 43)
3. handling the group process: allowing the group to reflect on past decisions and challenge them, instead of following a desire to research unanimous agreement (this concern was based on research on groupthink, see Esser (1998) for a review on groupthink).

The abstracted LLCP combined elements of storytelling (for addressing the first concern), root cause analysis (in particular, using a question structure called the Five Whys (Senge et al., 1994) for addressing the first concern), anonymity (to create an psychologically safe environment, addressing the first and last concern, see also Smith et al. (2007)), and facilitation of the group process. Further details on how these elements addressed the three concerns can be found in (Buttler and Lukosch, 2012).

In addition, the preparation phase resulted in an interview guide and a detailed questioning structure for lessons learned (see Section E.5.1 on page 288).

Box 10.1: General preparation and preparation of the interviewing phase in RefineryCol

Items in italics were specifically created for or adapted to RefineryCol. The other items indicate that the input may not have been created specifically for this case.

Identified themes and sub-themes Prior to RefineryCol, three potential themes for LLCPes in the RefineryProject were identified: operational, technical, and project management and execution. The last one formed the basis for RefineryCol. For the interviews, the theme was further divided into a hierarchical list of sub-themes (using stages of a project life cycle as a first level, and project management topics associated with these stages for additional levels). These sub-themes were intended for guiding questions in case the participants needed prompting for the topic selection, but not needed during the actual interviews.

Goal of the process Lessons learned were an established practice in OwnerOrg. Therefore, the main purpose and task goal of RefineryCol were adaptations of the purpose and task goals of other LLCPes found in OwnerOrg (no statements could be made about the uniqueness of the research purpose and task in OwnerOrg). Not surprisingly, the main difference to other LLCPes in OwnerOrg was their focus on the RefineryProject. Similarly to those other LLCPes, RefineryCol was set up to collect lessons learned in order to improve the performance of other projects. The focus on project management and execution was not a unique to RefineryCol – this theme was a high-level category for lessons learned in OwnerOrg.

Designed process In line with the research purpose of RefineryCol, the designed abstracted LLCP used in RefineryCol was unique to RefineryCol. The process design resulted in two abstract phases involving participants – the interviewing phase and the workshop phase, as well as an interviewing guide and a sequence of planned activities for the workshop phase (see following sections for the actual process).

Selected and informed participants Participants were invited based on their role and (temporal) involvement in the project (see also Table 10.1 on page 151). They included project managers (A4, A6, A7; as they carry the main lessons learned), individuals working on the project (A1, A2; providing the perspective of the "managed"), and other decision makers influencing the project (supervisors of project managers in the contractor organization (A3) and OwnerOrg (A5)).

Selected ground rules Ground rules were used in the interview phase (see Box 10.3 on page 155). These ground rules were aligned with principles of storytelling as well as collaboration. In general, they outlined behavioral norms and values on an individual and group level, and set expectations regarding the content and purpose of lessons learned and the LLCP.

Supporting Roles Two reasons for selecting the external team to support the LLCP could be identified. Conflicts within the project team were the main reason (see Environment in Section 10.1 on page 149). Due to these conflicts, neither a project-internal facilitator nor one employed by OwnerOrg were considered impartial. Apart from the no-stakes position of the external team, their extant knowledge of OwnerOrg and project management played a role in the selection.

Location All interviews were set up in meeting rooms (see Environment in Section 10.1 on page 149).

Selected and organized tools Tools and equipment for giving presentations were part of the rooms, and therefore did not need to be organized; other tools (for making audio recordings, and taking notes) were organized by the supporting team.

Prepare instruments for main phase The preparation of instruments used outputs from the various activities in the preparation phase. It entailed the selection of techniques for the interviews, as well as the creation of an interview guide (see Buttler and Lukosch (2012) for detailed design considerations).

10.2.2 Interaction Settings

RefineryCol used 5 interaction settings. Two interaction settings (the interview style and the individual work (RP)) did not require any interaction between participants. Instead, the participants communicated with individuals in supporting roles. With the exception of the F2F group (RP), the interaction settings allowed anonymous contributions.

10.2.3 Interviewing Phase

The interviewing phase (see Figure 10.1 on page 156) was used to obtain data for a first draft of lessons learned on project management and execution. In this phase, the 7 participants were interviewed separately. As a consequence, the order in which the interviews took place influenced the interviews itself. The interviews were planned for 90 minutes and lasted between 1 h 20 and 2 h (h stands for hour). Table 10.1 on page 151 lists the participants in the order of their interviews.

The abstracted activities across the interviews were rather similar. They consisted of 4 sets of activities. Apart from the opening and the closing phase, the core phase could be separated into eliciting context related to the participant (RPID1 & RPID2), and a set for eliciting and analyzing the situations, events, and expectations forming the foundation for the lessons learned (RPID3 & RPID4).

10.2.3.1 Interviewing – opening phase

During the opening of each interview, the interviewers used a presentation technique (without visual aids such as slides).

Table 10.2: Interaction settings in RefineryCol

	Interview style	Lecture style	GSS work (RP)	F2F group (RP)	Individual work (RP)
Expression mode (participants)	orally	verbally	verbally (mainly in writing)	orally	in writing
Anonymity	yes[a]	no	for written contributions	no	yes[b]
Interaction among participants	no	yes	yes	yes	no
Sub-grouping	-	no	-	no	-
Simultaneity	-	turn taking	-	turn taking	-
Relative Location	-	co-located	co-located	co-located	-
Synchronicity	-	same time	same time	same time	-

[a]With regard to other participants, not with regard to supporting team. Contributions made during the interview setting were associated with an alias in the following activities to maintain traceability.

[b]With regard to other participants, not with regard to supporting team.

In **RPIO1**, the interviewers introduced themselves (and their research). Optionally, in **RPIO2,** the lead interviewer briefly introduced an agenda for the remaining interview (referring to RPID2, RPID3, and RPID4) and set a time limit.

In **RPIO3**, the lead interviewer explained the approach taken for the LLCPes. This introduction explained the rationale for conducting separate interviews, and argued for it by contrasting it with collecting lessons learned in a single group session (presented as personal experiences, see Box 10.2 for the communicated disadvantages). The introduction varied slightly for each participant, depending on their experience with LLCPes, and their role in the project.

Box 10.2: Portrayed disadvantages of collecting LL in current approaches in OwnerOrg (RefineryProject)

Thesis: in normal LL sessions it is difficult to collect LL

- single group setting (presented as default for OwnerOrg)
- large group (20 people)
- duration: one to two days (which is too short)
- one participant talks, others are only listening
- technical experts usually not heard
- project manager speaks most of the time
- expertise of participants may not be relevant for LL discussed at the moment
- difficult to get or deepen everyone's story
- often only symptoms discussed, not root causes or what can be done about it
- for past conflicts involving the project manager, the discussion is more difficult when the project manager is present

In addition, the introduction laid down ground rules and key principles for the interviewing phase (see Box 10.3), and outlined activities following the interviews (referring to the analysis phase, and the workshop phase).

In two of the later interviews, the interviewer also shared first experiences with the interviewing process (e.g., explaining that the interviews led to very rich information, and that the same facts led to very different stories).

Box 10.3: Ground rules for the interview phase (RefineryProject)

Expectation Setting: Content and Purpose

- Capture both positive *and* negative lessons learned
- Context is important
- It is not about burning someone, not about sensitive information, but to get the general lessons learned out
- Discussion may include danger spots: risks when applying a lesson learned or situations when not to follow a lesson learned

Behavioral Norms and Values

- Present from your own viewpoint
- Speak freely

Expectation Setting: Post-Interview Rules

- Confidential information is kept confidential
- Personal information can be removed or generalized after the interview, which means lessons learned are not threating anymore
- Transcripts are only used by external team
- If the external team wants to do more with the interviews, permission from participant is asked
- Content will not be used outside the context of OwnerOrg
- Everybody gets a copy of the report

10.2.3.2 Interviewing – core phase

In the core phase, the interviewers elicited context related to the participant and collected data for the lessons learned.

To achieve these task goals, the interviewers utilized semi-structured questioning (see DPO1 in Section 7.2.2.2 on page 92 for a definition of the technique) as a technique, supported by personal notes and equipment for recording the interviews.

In **RPID1**, the context focused on a brief overview of the time a participant was involved in the RefineryProject (in terms of project phases), a participant's roles and responsibilities, and his involvement in other projects in the same program or at the same time. Optionally, participants also explained their professional background.

During this activity, two participants initiated an adaptation of the following process: they had already prepared lessons learned, and suggested an (oral) presentation of their results.

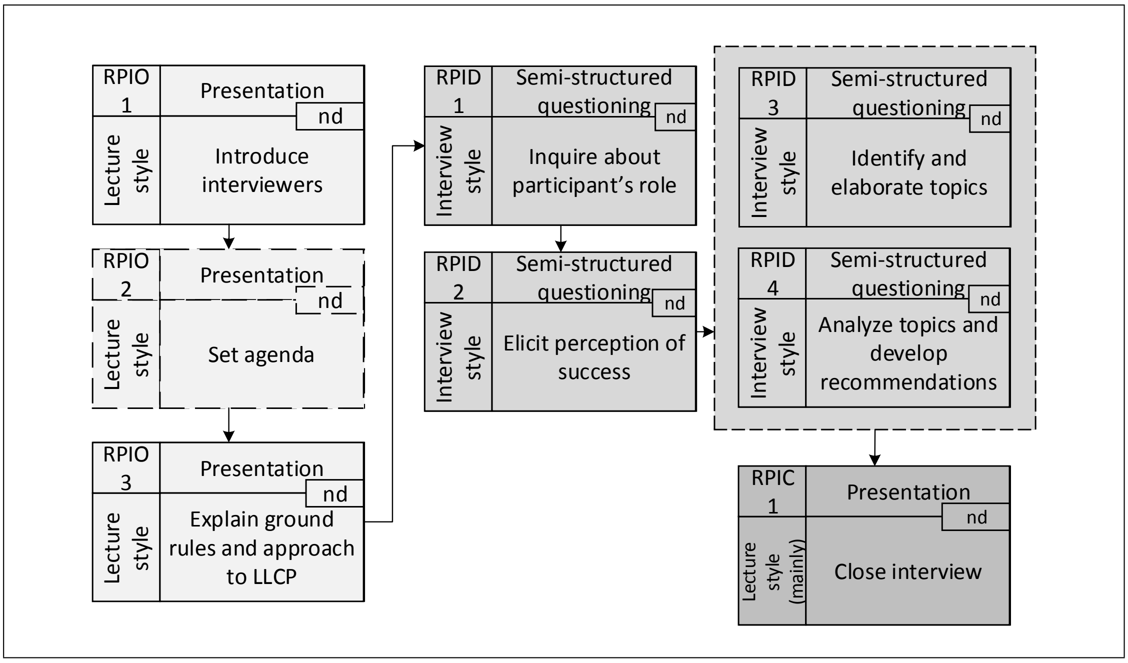

Figure 10.1: Process model for the interviewing phase of RefineryCol. Measures of duration are based on the length of the recorded interview and may exclude RPIO1.

In **RPID2**, the interviewer asked a participant how he defined success for the RefineryProject, and whether he considered the project to be successful. This activity was skipped for the participants who had prepared a presentation.

After first responses, this first answer was complemented with direct questions focusing on additional success criteria such as goals related to relationships between organizations. As a result, during RPID2, a mixture of participant-selected and interviewer-selected success criteria were elicited.

The participants did not just state success criteria, but also explained them and justified why they thought the project was successful or not. Table 10.1 on page 151 displays detailed results for this activity. As participants could (and did) choose their own definition of success for the project, the answers indicated that perceptions of success varied considerably. Participants defined success in terms of the project goal, as well as performance-related criteria (safety, cost, budget, and schedule). Overall, the project was perceived as successful in delivering a product, though the delivery was late. This late delivery could have threatened the license to operate for the refinery, and therefore threatened the purpose of the project. Regarding performance-related criteria, perceptions were mixed and dependent upon the success criterion. Delivering the project within budget and on time was considered unsuccessful, while perceptions regarding safety were positive. It should be noted that, during RPID2, no participant differentiated between different stages of the project (though A5 mentioned commissioning as a successful phase in RPID3/RPID4).

For both RPID1 and RPID2, the interviewer adapted the communication in order to prevent, discover, or fix deficiencies. First, the interviewer used summaries and confirming questions to allow the participant to discover misunderstandings. Second, the interviewer monitored the answers of the participant (see also Kolfschoten et al. (2011) for a similar intervention}, and used closed questions to ensure comprehensive answers, e.g., regarding the involvement in particular project phases such as the start-up of the product constructed in the project. Last, if a participant tried to deviate from these activities by addressing lessons learned or events associated with potential lessons learned, the interviewer would re-establish the focus of the activity by assuring the participant that a deeper discussion would follow in later activities.

In the following activities the interviewer aimed to identify topics or lessons learned (including a first elaboration on the context, **RPID3**), to analyze them and to develop recommendations (**RPID4**). Both activities included elements of storytelling to elicit the personal perceptions of events, situations, and expectations. In addition, RPID4 also used elements of a root cause analysis.

The planned interview (see Section E.5.1 on page 288) clearly differentiated between these two activities. In contrast, the actual interview dynamically switched between them, so that the two activities formed a set of semi-structured activities (see also Section 5.1 on page 68). The transition between these two activities varied both within and between interviews, allowing the interviewer to discuss one topic in depth before identifying the next topic, or collecting a list of topics, and then going through them one by one. In the latter case, RPID4 optionally started with a summary of the topic. The planned structure (identifying topics in one activity, and eliciting the lessons learned including their context in the following activity, clearly separated into two blocks) was not found in the interviews.

Also, for both activities the actual techniques and questioning structure were more intricate than planned. This section further presents these actual techniques and questions.

In **RPID3** several *techniques* were utilized to identify topics. The first technique, *semi-structured questioning*, was used during all interviews. Example questions are shown in Box 10.4 on the following page. These questions varied in their focus on positive and/or negative lessons learned, as well as the actor for whom lessons learned were developed (who should repeat something or do something differently in a future project). This actor could be the participant, his organization, somebody in a similar role in a future project, or the project team. Alternatively, the questions could be phrased neutrally (see the question for negative topics in Box 10.4 on the next page for an example). The second technique, a *presentation*, was only used if the participant had prepared a presentation prior to the interview and suggested using it. This presentation was integrated into the interview, and provided the foundation for identifying (and elaborating) part of the lessons learned. The next technique, identification through *association*, was used only within or after RPID4: a participant could suggest or select an additional topic associated with the one currently discussed, without being prompted to identify a topic. Also, the interviewer directly asked the participants whether something mentioned in RPID4 could be an additional topic or lesson learned. While these techniques asked a participant to identify the topics, the last technique, an *interviewer selection*, allowed the interviewer to select topics. These topics were based on events or remarks encountered in the context of another lesson learned in the same interview, or topics analyzed in previous interviews.

Outcomes. The response of the participants was not limited to a list of topics, but included stories elaborating the meaning of these topics. More precisely, participants elaborated events and situations encountered in the RefineryProject, voiced expectations (what should have happened in that project), evaluated events (was something considered helpful or not), and made assumptions about hidden goals and motivations of other participants. As the questions invited participants to identify lessons learned (and not topics), participants also started with a recommendation („we always should do [X]"), which could lead to a forward oriented analysis of the potential effect of this recommendation on the project, and a contrast with the actual events.

Quality assurance was used to improve (a) a list of (potential) topics, and (b) the story a participant told about a particular topic.

Regarding the list of topics, the interviewer (and to a lesser extent the second interviewer) summarized topics (in order to extract and maintain a list of topics, though this list was not shared in writing). The participant could then check for *completeness* and *correctness*, and add topics or correct misunderstandings.

Regarding the story of a particular topic, the interviewer used questions as well as prompts (that kept the participant talking) to obtain a more *complete* picture of the events in the project. The questions targeted expectations on what should have happened in the project, as well as effects.

Box 10.4: Identifying topics for lessons learned in RefineryCol

Starting question for identifying topics

- **For positive topics**: What did you see in the project that you will keep as a positive lessons learned and that you will try to repeat on your next projects?
- **For negative topics**: Let's now move to your most nightmare experiences on the project where you say, that should really be taken into lessons learned to really prevent this from happening on future projects and then again will try to find a little bit more the root causes but also solutions. Try to see how we could improve that. So what were the real major issues that you would list there?
- **Both positive and negative**: First let's list a couple of positive and negative lessons learned and then we go a little bit deeper and look for root causes for the negative ones etcetera.

After having identified (and optionally analyzed) lessons learned

- Other things you say in terms of lessons learned that we did not cover yet.
- Final one you have on your list. (for closing the interview)

In **RPID4**, the events, outcomes, or situations elicited in RPID3 were analyzed in more depth, and recommendations for future projects were developed.

Guidance. Similar to RPID3, the activity used *presentations* (if a participant had prepared one) and *semi-structured questioning* as its techniques. Example questions are shown in Box 10.5 on page 162. These questions typically focused on identifying what caused the events or situations identified in RPID3, or asked participants to propose actions[2] (something that is done or could have been done) for preventing them. The interviewer also asked whether a proposed action could have prevented the events. Overall, these questions were in line with the question structure proposed in the Five Whys. In addition, the interviewer atypically asked for indicators to define and recognize a risk.

[2]The term action is here used in its general sense, and does not have the special meaning (focusing on things to do on an organizational level) attributed to it in the cases involving MarineOrg.

The lead questions for identifying actions varied in their focus on positive and/or negative lessons learned. The questions in this activity could also suggest *boundaries* for the actions. With one exception, these boundaries used the RefineryProject as a reference point (could following the action have made a difference there, or did it contribute to positive experience there?). Second, similar to RPID3, these boundaries specified *actors* for whom lessons learned were developed (see RPID3 for examples for such actors). The questions could also imply *temporal boundaries* for actions. For example, by asking what could be done by the project team or „in a future project", the interviewer excluded the stages of a project prior to forming a project team (such as formulating a project goal), or actions targeting the organization as a whole (see also Chapter 3 on page 33). Typically (but with exceptions), the actor as well as the temporal boundaries mirrored the involvement of the participant in the project. Also, the boundaries could exclude *causes*: in one instance, the interviewer asked not to prevent the first cause, but to live with this cause and still try to prevent most (but not necessarily all) problems arising from it.

Analyzing a single topic. As part of the analysis, participants contributed (causal or intermediary) situations, (causal or intermediary) events, expectations, alternative actions, and recommendations (actions that should be done), as well as relationships between these components in all interviews. Events were described in detail and contained small stories, concrete examples, and developments within the RefineryProject. The recommendations included decision making criteria, artifacts (and how to use them), and other actions. The events referred not just to project management, but also contained personal regrets (A4) and how personal differences between

Expectations were contributed by either explicitly stating desirable situations or events (e.g., in order to form a counterweight to the negative events or impact experienced in the project), or in the form of an evaluation stating that something in the RefineryProject was insufficient. In addition to these, the interviews also contained evaluations of proposed actions (e.g., explicit statements that an action was insufficient or simple in the sense that once the problem was understood, the actual action to take was comparatively simple).

It should be noted that the *role of the interviewer* was not restricted to guidance on a process level. Rather, he co-constructed the context and recommendations on a content level. In relation to the events and situations in the RefineryProject and involved organizations, he suggested actual events or situations, evaluated events („really bad what happened"), and constructed downward oriented counterfactuals on the impact level (i.e., he outlined that the impact could have been worse). In addition, he suggested process steps or specific causes, as well as recommendations. Last, he formulated expectations. Based on his knowledge of project management and projects in OwnerOrg, he would explain an expected situation or event, and optionally contrast them with actual situations or events, for example. In some of these instances of co-construction, the interviewer asked for confirmation from the participant - with the participant confirming, correcting, or rejecting the interviewer's contributions.

The *knowledge base* for the analysis was not limited to the RefineryProject – rather, the analysis of the interviews indicated that the interlocutors based their contributions on three types of sources. First, the contributions were based on interpretations of what happened in the RefineryProject. As suggested in the basic model, the participant used his own memories of actual personal expectations and experiences in the RefineryProject or the associated program. The participants also referred to second-hand information by recounting what they had heard about aspects of the project they were not involved in. In the same strain, the interviewer used insights from his preparation for the interview as well as information from previous interviews. Second, the participant (rarely) referenced specific other projects, events or situations that had no direct relation to the RefineryProject (e.g., in order to suggest a recommendation as something that was done in the past in a different project). Last, while these contributions were based on specific past events or situations, both interlocutors also relied on their domain knowledge on projects in the oil and gas industry (e.g., referring to normal projects that did not encounter the events experienced in the RefineryProject).

During the interviews the interlocutors had no access to files (beyond the presentations) or to other participants. Apart from recognizing and acknowledging this gap, the participants also attempted to cope with it by replacing the missing information with their own assumptions or conclusions (e.g., „I also get the feeling that there were other competitors which [. . .]" and „I cannot imagine that we promised the [external stakeholder] this [scope]").

On a coarse-grained level, two types of *structures* (or flows) could be identified for the analysis. The first flow started with symptoms (events/situations at the end of a causal chain in the project), then moved to identifying potential causes followed by options (as actions) for breaking the causal chain or reducing the impact of the identified causes. Mental simulations[3] (see below for details) could be used to assess whether the actions had the potential to change the outcomes in a project. Alternatively, the interview could start with lower level events or even first causes, and then moved to identifying recommendations (resulting in a partial flow through the structure). The second flow started with a recommendation, and the interlocutors then (a) identified situations and events (in the RefineryProject or on a generalized level) influenced by this recommendation, (b) clarified details regarding the recommendation (how to do something), and (c) identified causes that were addressed with this recommendation.

On a more detailed level, the analysis of the topics involved causal analysis, and *simulations* of the effect of suggested recommendations. Domain knowledge (including knowledge on generic other projects) was used as a contrast for identifying causes (with a question like: „what was different or special in the RefineryProject?"), and to understand causal relationships.

Both in order to complete the set of recommendations and in order to check for the viability of suggested recommendations the interlocutors would (mentally) simulate the effects of the proposed actions on the RefineryProject, e.g., by asking whether the actions would lead to the absence of negative experiences/effects encountered in the project. These simulations could simply result in insights into the effect of following a suggested recommendation, e.g., whether the recommendation was sufficient to address a problem (stopping without further analysis). Alternatively, they were iteratively used to develop new recommendations and modify extant ones in order to obtain a viable

[3] Both the causal analysis and the analysis of the effect of recommendations observed in the interviews resembled mental simulations, which in turn are thought processes involving an operation resembling the running of simulation models (Kahneman and Tversky, 1982). The observations relate to communicated simulation, though. A mental simulation can vary with regard to changes made to a starting condition or constraint and whether a target state or event is set.

set of recommendations. These lines of questioning were partially driven by domain specific questioning, but also more general questions could be identified (e.g., „How do we change that? The [artifact] is one. Is there more necessary to change this? Because I don't think that the [artifact] will immediately drive the [desired effect].").

While these mental simulations tested and developed recommendations, others were used to improve the understanding of potential consequences in a project. Here, the interlocutors moved from a cause to (imagined or unknown) consequences that could have occurred in the RefineryProject, assuming that the project team would do nothing to break the chain of events. This simulation resulted in a list of further influences (for which it was unknown whether they had taken effect), e.g., in the form of a list of processes such as value engineering that could have been impacted negatively by the cause.

Regarding the boundaries for proposed actions, the participants generally followed them or set their own (based on their involvement in the project). However, exceptions did occur. For example, one participant was asked for a recommendation for his own organization, but explicitly suggested a recommendation for the other organization. In another instance, a project manager (and the lead interviewer) explicitly acknowledged that a proposed action would have been beyond the control of the participants.

Even though the interviews were performed one at a time, *interviews could influence each other*. For example, in one instance, the interviewer summarized another participant's perspective on a topic (a perspective the current participant disagreed with). More commonly, the interviewer mentioned that some topics had been addressed in prior interviews (presumably to establish common ground and potentially influencing the motivation by indicating that other participants found the topic important as well). In contrast to these backwards-oriented relations, the interviewer could also indicate that a question could be settled in an upcoming interview.

Relationships between topics. In addition to this analysis focusing on a single topic, the activity also identified relationships between topics, though this was not done systematically throughout the interviews. Reviewing or summarizing key aspects of the topics helped the interlocutors to identify cross-connections between recommendations and events mentioned under other topics (at the end of RPID4). Participants also identified connections on a causal level, where a root cause from a prior topic was considered a cause for the current topic as well.

Quality assurance during this activity was diverse, and had the potential to influence a participant's motivation to share his experiences, to focus the activity on a topic, and to improve the quality of the lessons learned with regard to several quality dimensions.

First, regarding a participant's *motivation*, the interviewer encouraged participants and the conversation to the purpose of the LLCP by stressing that a particular topic or elicited lessons learned was important (e.g., by pointing out that the causal events or topics could occur in and have a high impact on other projects as well). Also, he explained why certain details needed to be shared even if they might not be describe in the final lessons learned (first go into detail in order to be able to generalize from it).

Second, when an additional topic for a lesson learned was identified during the ongoing analysis, the interviewer would shelf that topic, and assure the participant that it would be picked up again at a later point in the interview.

Last, the interviewer addressed several quality aspects relating to the *content* associated with a topic. In simple instances, he would repeat or rephrase a question to elicit a specific (otherwise missing) contribution. Also, the (mental) simulations and the formulation of contrasts between generic projects and the RefineryProject (see above) can be considered components of the activity aiming to prevent, discover, and fix deficiencies regarding the *viability* of recommendations, the *completeness of the set of recommendations*, and to obtain *additional consequences* that particular causes could have on a project. Similarly, iterative questions along the line of „anything else?" asked in order to obtain a more *complete set of recommendations or causes*.

To increase the *level of detail*, the interviewer used summaries and remarks as prompts for further elaboration, and direct closed questions for obtaining particular details. Open question (how to do something) was used for obtaining more specific recommendations.

To prevent *misunderstandings* and check for *correctness*, the interviewer checked his understanding and asked for clarification by inferring recommendations or summarizing contributions, and asking for confirmation or providing an opportunity to correct (which the participants used). In addition, formulating contrasts with generic other projects was used as an approach to confirm that differences to these generic other projects were understood correctly. Last, the interviewer intervened to organize a contribution as either symptom or cause (presumably in order to improve the quality of the *causal analysis*).

Box 10.5: Questions for the in-depth analysis of topics in RefineryCol

For positive topics

actions - general Were there some [things] that helped and contributed to that, that you would advise to repeat? Was there something done [to achieve the positive outcome]?

For negative topics

root causes "If we look a little bit at root causes here, because I think that is important for the lessons learned. [. . .] So what really went wrong. I mean it is not because [events mentioned in interview]. I think it is much deeper than that."

root causes & risks "What your thoughts, could you deepen that a little bit, look a little bit at root causes there. What really goes wrong there in such a [situation]? What are those risk? What did you watch out for. How can we recognize that?"

actions - general "What would you advise *your team* next time or what would *you* drive next time? What did you learn from this? How would you do it differently?"

actions - prevent "Any thoughts on how, what could have been done to prevent this from happening and what is your suggestion for a future project?"

actions - prevent/control "At the start of this project [that option] was not available, but recommendation one is of course make sure its available. Suppose that is not possible, what would have been the best options to still prevent a lot of problems from happening. What would have been the necessary minimum to do in order to overcome problems or maybe other alternative solutions?"

10.2.3.3 Interviewing – closing phase

The interviewer used the closing phase (**RPIC1**) to

- thank the participants

- to stress positive aspects of the interview by reviewing the strengths of the approach and the (positive) value of each participant's contributions (manipulating satisfaction)

- briefly inform participants about what happens in the intermediary phase, and informing them that a workshop phase is planned (expectation setting)

- ask participants to suggest additional interviewees (continued participant selection) or topics to be discussed with

- to discuss approaches for retrieving and using lessons learned (e.g., via a risk register)

10.2.4 Intermediary Phase

The intermediary phase was concerned with the analysis of the interviews, and the preparation of the workshop. To prepare the analysis, the interview material (about 10 hours) was partially transcribed (resulting in 255 pages). The transcripts focused on the core phase of the interviews, and excluded opening and closing phases. The analysis itself used qualitative data analysis to identify lessons learned. It resulted in a preliminary report (28 pages) containing 31 problem statements and 56 recommendations. These problem statements were clustered into 8 themes (all but one sub-themes of project management). The problem statements and the recommendations were associated with anonymous identifiers to maintain traceability.

Similarly to the overall preparation of the LLCP, the workshop phase required its own preparation (see Box 10.6 for the input created during that preparation).

Box 10.6: Additional input for the workshop phase in RefineryCol

Items in italics were specifically created for or adapted to RefineryCol. The other items indicate that the input may not have been created specifically for this case.

Identified themes and sub-themes The 8 categories identified during the analysis were used to organize the lessons learned during the workshop.

Selected and informed participants All interviewees also participated in the workshop. The workshop had no additional participants, and one additional observer from OwnerOrg.

Selected ground rules Ground rules were selected for the workshop phase (see Box 10.8 on the next page). In general, they outlined behavioral norms and attitudes on an individual and group level.

Location The workshop used a traditional meeting room design (see Justice and Jamieson (2006)) with one area for a presentation at the table head.

Selected and organized tools Tools and equipment for giving presentations were part of the location, and therefore did not need to be organized; other tools (the GSS, laptops, equipment for making audio recordings) were organized by the supporting team.

Prepare instruments for main phase The preparation of instruments used outputs from the various activities (e.g., tool selection, and the analysis of the interviews). It included the selection of techniques for the workshop, the preparation of a presentation for the opening phase of the workshop, and the configuration of the GSS with shortened problem statements and recommendations that were the result of the analysis of the interviews.

10.2.5 Workshop Phase

The analysis of the interviews resulted in a multifaceted view on several topics. The participants reflected on these combined results in a facilitated workshop that took place at Delft University of Technology.

The workshop itself consisted of an opening phase, a core phase, and a closing phase (see Figure 10.2 on the facing page). Its main tool support consisted of a group support system (GSS, see also Section 5.2 on page 69) allowing the participants to work anonymously and in parallel.

10.2.5.1 Workshop – opening phase

The opening phase consisted of four activities (**RPWO1** to **RPWO4**), all of them using a presentation technique (with slides) combined with the lecture style interaction setting. Members of the supporting team performed as presenters, with the participants as the audience.

These presentations were used to create a brief overview of results from the intermediary and the preparation phase, and to introduce participants to the workshop.

More precisely, in **RPWO1** the participants were presented (verbally and in writing) with the approach to collecting lessons learned and results of the LLCP so far. The latter included an overview of the themes for lessons learned developed in the previous phase, and a causal diagram indicating the major causal relationships between problems encountered in RefineryProject. In line with the expected research outcomes in the project, a proposal was made to integrate lessons learned into a wiki in order to support the presentation and dissemination of lessons learned in the organization.

Box 10.7: Agenda for the workshop phase (RefineryCol)

Introduction[a] : Presentation of approach and results, introduction into the GSS, establishing ground rules (20 min)

Evaluate the lessons learned : Commenting on lessons learned and descriptions of situations; (optional) add new lessons learned (60 min)

Tagging of the lessons learned : Adding keywords and tags to the (problem) situations (15 min)

Voting : Evaluate each topic on consequence, probability, importance for project using a 5 point scale (15 min)

Evaluate process[a] : obtain (qualitative) evaluations on the LLCP

[a] Not listed on the written agenda shown to the participants

The following activities focused on the particularities of the workshop: its agenda (in **RPWO2**, see Box 10.7 for an extended form of the agenda), the concept of a GSS (in **RPWO3**: its advantages and supported collaborative processes), and ground rules (in **RPWO4**; see Box 10.8).

Box 10.8: Ground rules for the workshop phase (RefineryCol)

- Sta open voor elkaars ideeën (Be open for each other’s ideas)
- Reageer inhoudelijk, gedetailleerd (React on a content level, with details)
- Lezen = Luisteren (Reading = listening)

- Denk out of the box (Think out of the box)
- Probeer precies te formuleren (Try to formulate precisely)

The original was in Dutch (translation was added by the researcher).

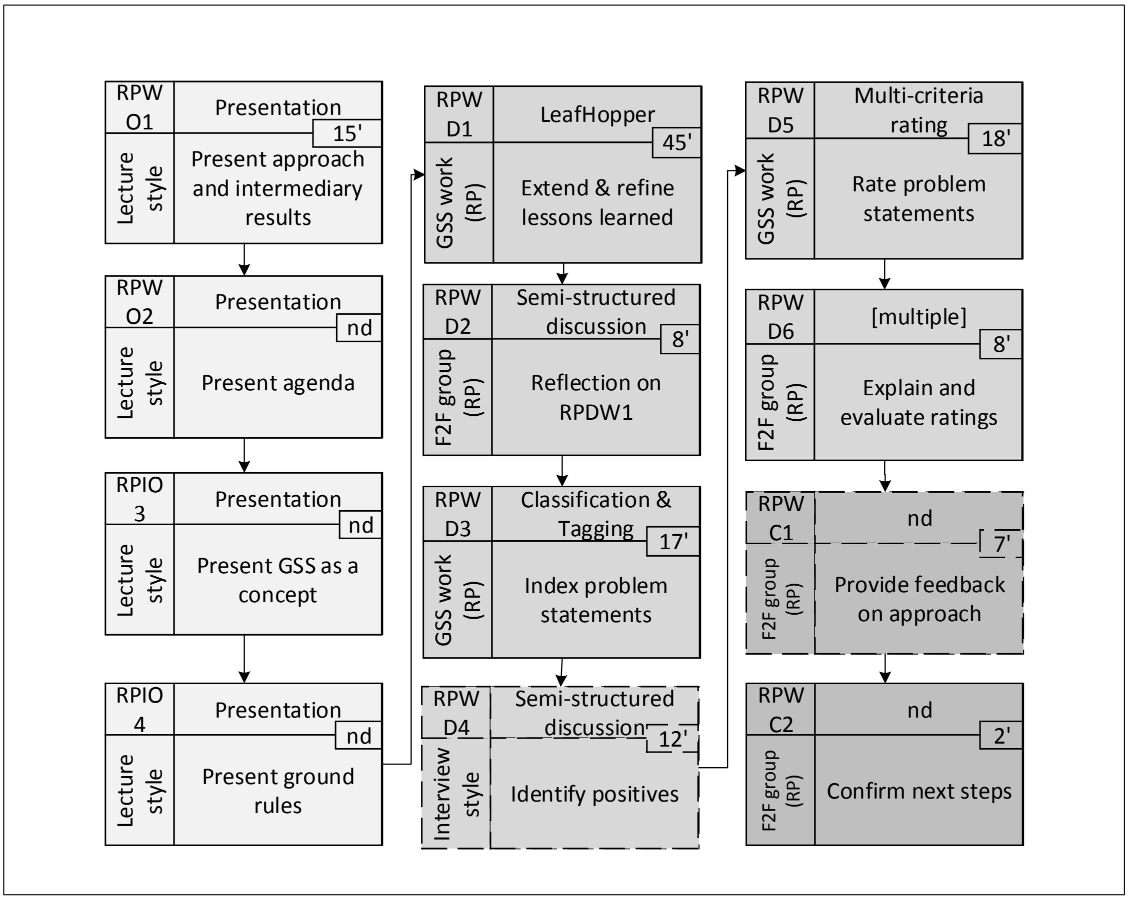

Figure 10.2: Process model for the workshop phase of RefineryCol.

10.2.5.2 Workshop – core phase

As indicated in Figure 10.2, the task of the following activity was to extend and refine the problem statements and recommendations lessons learned resulting from the previous phase (**RPWD1**). This activity utilized the technique LeafHopper (see Appendix C on page 263), was supported by the GSS as the main tool, and took place as self-assigned group work.

The technique was configured with a main prompt („Verify lessons learned: please add missing problems, solutions, and different perspectives/comments”), as well as content obtained from the analysis of the interviews. The content in the LeafHopper formed a forest, with each tree having a depth of 4. The themes from the intermediary report took the place of the topics in Appendix C on page 263, and therefore were the root nodes of the trees. Below these themes, problem statements formed the main ideas. The children of each problem statement were a prompt „problem reflection” and extant recommendations. The last layer consisted of comments (contributed by participants).

The participants could comment, e.g., in order to correct or extend the problem (under problem reflection) or the recommendations. They could also add new recommendations to a problem statement, but they could not identify new problems. Overall, the participants contributed 19 comments as problem reflections, 26 recommendations (estimated lower bound; resulting in a total of 71 recommendations in the GSS), and 70 comments on recommendations. All of these contributions were made in written English. Orally, the participants also shared information on abbreviations used in OwnerOrg, asked about and commented on the interaction with the GSS, and joked and laughed (in Dutch or English).

Quality Assurance. Regarding *deficiency prevention*, the facilitator monitored the input and asked the participants to provide recommendations for problems that did not have solutions, as well as to answer open questions posed in the content (if necessary, by specifying the particular problem where the open questions were placed), thus performing a check for *completeness*.

The intermediary reflection in **RPWD2** allowed participants to comment on the previous activity in a group discussion that involved the participants as well as members of the support team. More precisely, the facilitator asked about the key remarkable thing, things that were missing or interesting findings. As a result, the participants (a) criticized the strong focus on negative issues (and developed potential explanations for this focus), (b) discussed whether a separation of topics into technical and project management was needed (the latter being the focus of the LLCP), and (c) reflected on one problem description that a participant found hurtful. Also, on a relationship level, the program manager (A5) asked representatives of the contractor whether there were any remarks or lessons learned they were uncomfortable with. As a consequence of the remarkable focus on negative issues, the facilitator adapted the process by adding an activity for briefly listing positive issues (see RPWD4).

During **RPWD3**, participants manually indexed the problem statements. This activity utilized two techniques: a classification of the problem statements on multiple dimensions, and tagging (see also RCA5 in Section 8.2.3 on page 115). As lessons learned can be considered potential risks for future projects, the classification was configured with the TECOP framework (a framework for describing sources of risks used in OwnerOrg, see also Hillson (2003)). The framework contained 6 categories which were mapped to the dimensions of the classification technique. In turn, each category contained multiple concepts. Participants were asked to assign those (free) keywords and concepts from the TECOP framework that they expected to be useful for the retrieval of the problem statements. They were also instructed to skip a category if they found it to not be applicable for a problem statement. On a tool level, the activity was supported by a grid view in the GSS (problems being presented in the row, the categories for indexing and a field 'other' for free tagging).

Regarding *deficiency prevention*, the facilitator used constraint re-emphasis to keep the focus on describing problem statements for later retrieval. Furthermore, the classification framework was used in OwnerOrg as part of the risk management in projects. Thus, several participants were already familiar with it, which reduced the potential for misunderstandings. Also, the facilitator offered technical guidance and explanations on how to use tool.

However, not all deficiencies were prevented during this activity: due to the tool selection, only the last selection of the participant was recorded (which was an issue for tagging, as this activity did not leverage the multiple perspectives represented by the participants).

Similar to RPDW1, the activity was accompanied by chatter and laughter, and the participants used oral communication to reflect upon the techniques and configuration of the activity.

Overall, the 31 problem statements were indexed with 60 keywords from the TECOP framework and an additional 20 free tags.

In **RPWD4**, the facilitator adapted the planned process with an activity that allowed participants to list positive lessons learned (introduced as „things that went well in the process") using a semi-structured discussion as a technique (it was allowed to contradict or challenge each other ideas). It is noteworthy that the participants had difficulties identifying anything positive about the project at first. They started with identifying outcomes of the project resulting in a negative or neutral evaluation of internal success criteria (e.g., budget, safety), and a positive evaluation regarding the outside perception of the project outcome.

Regarding *deficiency discovery and fixing*, the facilitator had to contradict a voiced assumption of the participants („daar is eigenlijk niet veel wat daar is good gegaan" - there is not much that went well there; challenged with „think that shouldn't be the case." and combined with a rephrasing of the original question). For one positive idea (a positive state in the project) the facilitator used additional questions to elicit more details on the recommendation: „are there things that made it work like that? Is it [X or Y]? Or what is the trick?"

Overall, the facilitator recorded nine statements (94 words) which partially overlapped with the intermediary report. These statements covered events and situations (e.g., „[Role] was present from start [project phase]"), outcome information (e.g., „[External stakeholder's] reputation strongly improved by delivery of project.", and causal attributions, e.g., „[Characteristic of product] helps availability as [. . .]").

Next (**RPWD5**), participants were asked to rate the problems underlying a lesson learned. This activity was used to obtain an overview of how important the problems were considered, and relied on the subjective opinion of the participants. It used MultiCriteria rating with three criteria (severity of consequences in future projects, (perceived[4]) probability of re-occurring, and impact on the RefineryProject), each on a 5 point scale (1: low, 5:high).

Regarding *deficiency prevention*, participants were allowed to skip a rating, potentially preventing them from providing a rating for a problem for which they lack the knowledge to rate it (see also Section 6.1.5 on page 83). Furthermore, the rating used criteria that some participants were familiar with, as the criteria severity of consequences and probability were also used for risk assessment (see, e.g., (Hillson and Simon, 2007)) in OwnerOrg. A scorecard (also used as part of the risk management in OwnerOrg) was used to define a meaning for the criteria (perceived) probability of re-occurrence and consequences, and objectify the ratings (e.g., a rating of *1* for (perceived) probability of re-occurrence would mean that the problem was estimated to re-occur in 1 out of 100 projects). The scorecard also specified categories of consequences (people/safety incidents, damaged assets, effect on the environment, costs, and reputation). On the

[4] The term perceived was not used in the workshop, but has been added here to avoid misunderstandings. The participants did neither calculate probabilities nor did they use the probability range from 0 to 1. Thus, the ratings can only be assumed to be perceptions, not actual probabilities.

downside, these categories meant that consequences measured several factors (a score of 5 for consequences could mean an international impact on reputation, or costs exceeding 1 Mio $). Last, the facilitator used constraint emphasis by explaining the criteria and keeping them (and the scorecard) visible during the rating (see also (Kolfschoten et al., 2011)).

The activity resulted in 5 to 7 ratings per criterion and problem statement. This indicated that participants actually used the option to skip a rating. Similar to RPDW1, the activity was accompanied by chatter and laughter.

To prevent deficiencies, the facilitator emphasized which criteria applied to future projects and which ones to the RefineryProject. Also, the facilitator offered technical guidance and explanations on how to use tool.

In **RPWD6**, the ratings were explained and evaluated. This activity was supported by the GSS, which provided descriptive statistics (the mean and standard deviation for each combination of problem and criterion). The participants could create scatter plots (re-creations are shown in Figures 10.3 to 10.5 on the next page) through their browser interface in order to visualize distributions and how the criteria relate to each other (supported by technical assistance from the facilitator). Apart from the techniques for the statistical analysis and the data visualization, this activity also utilized a presentation for the analysis of the results, and an open discussion (which is a technique similar to semi-structured discussions introduced in DPD6 in Section 7.2.2.3 on page 98; but apart from a given discussion topic, participants are responsible for giving structure to the discussion).

In her analysis, the facilitator focused on the spread of the ratings (measured through the standard deviation) as an indicator for the level of agreement between participants. She concluded that, considering the group size and with a few exceptions, the standard deviation was pretty small, and agreement therefore high. A discussion explaining deviations (and therefore variations in opinions) was not performed. In the open discussion, participants started to explore the meaning of the ratings. They identified three ways of using these ratings. First, one participant asked for a comparison with similar projects, and an assessment on whether the charts were typical for projects similar to the RefineryProject. However, other participants pointed out that such a comparison was not available. Second, they suggested using these ratings in future projects (optionally in combination with the tagging approach) for selecting the most important lessons learned to work on (also suggesting that it would be rather hard to work on 30 to 40 lessons learned at once). Last, they identified an opportunity: if tagging and rating would be performed consistently for every project OwnerOrg could build a database that allowed searches such as: what are the most important problems for team building.

10.2.5.3 Workshop – closing phase

In the closing phase, the participants first initiated an open discussion for providing feedback on the approach in the LLCP in **RPWC1** (see Section E.5.3 on page 290). This was followed by an activity (**RPWC2**) listing and obtaining agreement on the next steps after the workshop: providing an opportunity to comment on the report via email, and sending copies of the workshop output (automatically generated by the GSS) and the final report to the participants.

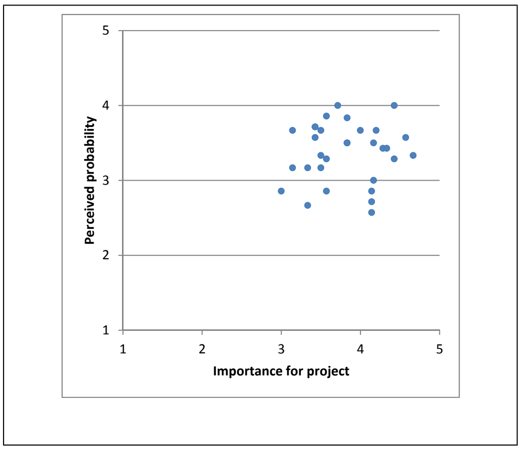

Figure 10.3: Distribution of problem ratings: mean (perceived) probability of reoccurrence against mean impact on the RefineryProject

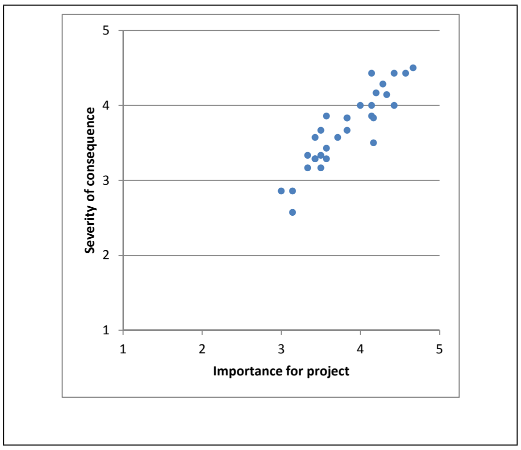

Figure 10.4: Relationship between severity of consequences in *future* projects (mean ratings) and importance for the RefineryProject (mean ratings).

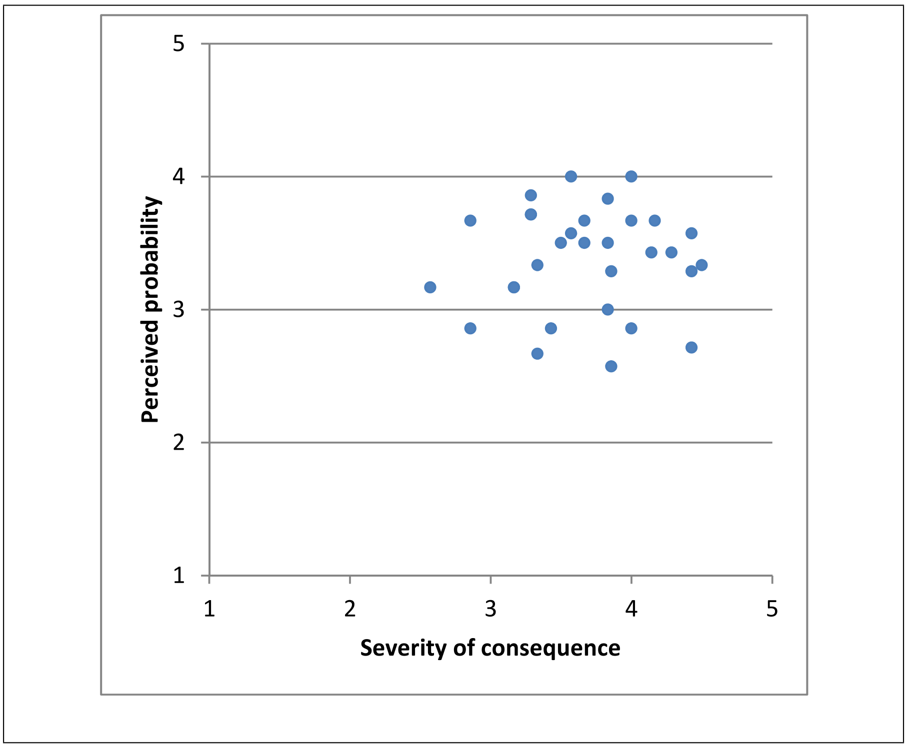

Figure 10.5: Distribution of problem ratings: mean (perceived) probability of reoccurrence against mean severity of consequences.

10.2.5.4 Post-processing Phase

The post-processing phase included the following activities:

1. Participants were asked to provide additional comments via email
2. The report was extended with an introduction and a summary (that also used the

rating results)

3. The drafted lessons learned were edited based on comments from the workshop phase and the emails
   (a) The lessons learned were further anonymizing the report by replacing a vendor name with its role
   (b) They were connected to the data (see next section)
   (c) Problem statements were merged or removed based on the participants' comments
   (d) Recommendations were updated
4. A lessons learned register in the form of a spreadsheet was created
5. The final results were disseminated to all participants, and stored in the designated repository in OwnerOrg

The post-processing resulted in a report containing 24 problem statements (lessons learned). These problem statements were still clustered into 8 categories. It should be noted that neither the tagging nor the positive statements were used in the report.

10.3 Characterizing the Collected Lessons Learned (RefineryCol)

The set of lessons learned. RefineryCol resulted in 24 (1 positive, 23 negative) lessons learned (reduced from 31 problem statements presented in the intermediary report). All focused on process knowledge. The lessons learned were still clustered into 8 (re-phrased) themes.

Structure of the lessons learned. Observations regarding the documented negative lessons learned are summarized in Table 10.3 on page 172. The negative lessons learned contained at least an introduction or problem statement. Each lesson learned listed between 0 and 5 recommendations (median: 2). 9 lessons learned included consequences under a separate subheading. 6 lessons learned used additional fields to express an individual storyline (see 'other' in Table 10.3 on page 172). Elements found in other cases such as expectations and causes were typically integrated into the introduction or problem description. It was noteworthy that the negative lessons learned described actual (what happened in the RefineryProject), as well as hypothetical events and situations. These hypotheticals included intentions from the beginning of the RefineryProject that did not come to pass, and unrealized consequences (identifying near misses as well as missed opportunities). Hypotheticals were also used to describe what a different approach would have meant in the RefineryProject.

The only positive lesson learned stated a problem (how to do something) instead of a situation, used recommendations to outline a high-level approach for a solution, and a subsection *Results* to report on actual events and consequences (in terms of time gained through the approach).

All in all, the report did not use a uniform structure for its lessons learned, though the lessons learned typically shared some common structural elements (namely a problem, and recommendations providing instructions on what to do).

Recommendations. The recommendations for negative lessons learned focused on what to do differently in order to prevent the events or situations encountered in the RefineryProject. Recommendations could achieve that suggesting ways of how members of the project team (or other roles represented by the participants) could have prevented the causes or effects of the causes. However, not all potential causes could be prevented by the project team. For such lessons learned, two approaches were found. First, recommendations could focus on what the project team or project manager could do in such a situation in order to reduce the effects of the causes. Alternatively, the lessons learned could make recommendations for individuals who were not part of the project team. For example, one lesson learned recommended activities that had to be performed by the refinery; typically before the project team was formed (breaking the temporal boundaries of the project). Another two addressed attitudes or behavior and procedures outside of the control of the project team or the project manager (e.g., asking external quality assurance to change their behavior).

Connecting the lessons learned to the data and intermediary results. The resulting lessons learned were based upon the data gathered in the LLCP. The report contained a table listing interviewees who had contributed to a lesson learned during the interviewing phase, identifying participants associated with OwnerOrg by name, and participants associated with the contractor as „EPCm contractor". The lessons learned used direct quotes from the interviews to illustrate the explanations or the impact, and to ground the results in the data. In addition, the assessment (obtained in RPWD5) was used to present two lists of lessons learned – one with the five most important lessons learned for the RefineryProject, and one with the top 5 lessons learned when combining the (perceived) probability of re-occurrence and the consequences for future projects (see also Figure 10.5 on page 169).

However, not all intermediary results were included in the lessons learned: the complex cross-connections documented in a causal diagram were not included, and only one lesson learned explicitly referred to another lesson learned.

10.4 Evaluation (RefineryCol)

The evaluation of RefineryCol consisted of a survey (Section 10.4.1) issued to the 7 participants for evaluating the outcomes of the process, and an interview with the program manager (Section 10.4.2 on page 173).

10.4.1 Survey

10.4.1.1 Demographics

The respondents (7 men, all Dutch) covered an age range from 30 to over 55 (see Table 10.4 on page 173 for more details). They had between 5 and 43 years of work experience (median: 20 years)

Table 10.3: Characterizing drafted lessons learned (RepositoryCol)

Key element in a LL	Referring to	Presented under the subheader(s)	Content
Title			Topic of the lesson learned
Problem or Introduction	Generalization or RefineryProject	Problem, Details, unlabelled, Symptoms (once)	Always contained a description of decisions, undesirable situations/ states or events in the project – or of generalizations thereof. For some LL, these generalizations were phrased as a question (how to achieve a desirable situation or how to do something). The type of content was diverse: the problem description could focus on the past by including details of the development in the project, or assumptions and reasons influencing a decision. Some LL explicitly identify causal factors or mechanism. Descriptions of expectations, an alternative scenario (what would have happened if the situation had been different), a comparison with other types of projects, and an assessment of the importance of a problem could also be identified
Other	various	normal case & differences in project; original plan, turning point, resulting idea; (root) cause; situation; conflicting experience	LL could have individual storylines expressed in the sub-headers (separated by a semicolon in the left column), e.g., contrasting a “normal” situation with the situation encountered in a project, or using these sub-headers to outline a development in the project.
Consequences	Generalization or RefineryProject	Consequence	Generally included the immediate consequences of the problem. Detailed undesirable specific events or situations in the project resulting from the problem description, for example. Consequences could also include unfulfilled expectations or general impacts on project performance (e.g., on quality of the product and on schedule).
Recommendation(s)	future projects or (rarely) actors outside a project	Recommendation(s)	Instructions on what to do differently by suggesting actions that typically had not been followed in the RefineryProject (presented with the imperative or using “should”). Presented either as unstructured text, or using main instruction as a sub-header followed by detailed explanations. In their simplest form they negated actions or decisions taken in the RefineryProject (this could be identified in 4 LL). They could contain alternative courses of actions (i.e., choose one recommendation instead of follow all recommendations), and decision trees. Statements that recommendations have been followed in other projects or in part of the same projects were rare, but did exist in at least 2 lessons learned.

Table 10.4: Age groups (RefineryCol)

Age Group	Frequency
30 to 34	1
35 to 39	2
40 to 44	1
45 to 49	1
50 to 54	0
55 or older	2

10.4.1.2 Perception of process outcomes

The respondents' assessment of the process outcomes is displayed in Table 10.5.

The responses indicated a weak satisfaction with the results of the workshop and the interviews, and a positive commitment towards these results.

Table 10.5: Perception of process outcomes (RefineryCol)

	N	Median	Q1	Q3
Satisfaction with results	7	4.2	3.8	4.8
Commitment towards LL	7	5	4.6	5

10.4.1.3 Qualitative results

The resulting report received mixed comments: from good or useful (together 3 participants), to „theoretical" (1 participant). Also, one participant objected to the strong focus on negative experiences.

The overall **process** was considered good, with the potential for improvement. One participant indicated that his evaluation of the process took into consideration that the abstract LLCP was still and a design and test phase, and used this to explain its shortcomings. For the overall process, the independence and the analysis were considered positive (1 participant), while the speed of delivery was too slow (1 participant). Participants mainly considered the interviews to be successful: it was considered „prima" (5 participants), useful (1 participant), efficient (1 participant), and it had the right depth (1 participant), but it was also too short and focused on a single goal (1 participant). The participants also suggested the workshop should to be improved. In particular, they remarked that the workshop was less efficient (1 participant) and too short. Also, one participant expected the workshop to deepen his understanding of the lessons learned, and to clarify them. The methods in general (1 participant), the tools (1 participant), and tagging (1 participant) needed to be improved.

10.4.2 Ex post: Interview with the Program Manager

An interview with the program manager was used to further evaluate the LLCP. The interview delivered insights into the usage of the collected lessons learned, into their perceived quality, and into the perceived quality of the LLCP.

Usage of the collected LL. The interview identified three types of instances for the serendipitous usage of lessons learned.

First, the interview identified one lesson learned that was used to initiate solving a problem. The cause and the recommendation provided an initial idea for a solution. Interestingly, the cause identified in this lesson learned fell outside the project team's area of influence. As a consequence, the interviewee and a stakeholder (the business side) not represented in the LLCP were involved in the initiatives to deal with the cause.

Second, some of the lessons learned were used in conjunction with other developments in OwnerOrg. This usage involved raising awareness about clusters/themes of problem situations. Lessons learned could confirm what was happening in other projects or, the other way around, identify a problem that was then discovered as a company-wide issue (thus helping users to identify a potential problem).

Last, the contractor used the resulting lessons learned for their own LLCP, also because they had lost some projects with OwnerOrg. The combined results were reportedly used to change the contractor's way of performing the project.

Perceived quality of LL. The overall quality of the reported lessons learned was good. They were easy to read, and there were no major gaps with regard to the topics covered in the lessons learned. Also, it presented the whole storyline.

On the downside, the structure of the lessons learned was perceived as not always consistent and one lesson learned was factually incorrect. In addition, while the report contained the whole storyline, this made the lessons learned more difficult to use compared to lessons learned presented in a spreadsheet.

Most importantly, some recommendations were perceived as impracticable – „the difficulty always with lessons learned is: what can you do if you read it again in a new project". This statement summarizes two aspects: specificity of the recommendations (some seemed to not specific enough with regard to decision making criteria or instructions for a project team), and what can be influenced in a new project. Regarding the latter, one recommendation was not practicable because of the temporal boundaries of the project (e.g., because the project team was not involved yet), while another recommendation addressed factors that was not easy (for a project manager) to influence.

Perceived quality of the LLCP. The interview identified three positive, one mixed, and two negative aspects of the LLCP. On the negative side, the effort for the supporting roles, and therefore the costs were too high for the RefineryProject (confirming challenge **Env5** on page 62). Furthermore, the process (particularly the intermediary phases) took too much time. Due to this delay it was more difficult to use lessons learned in projects running in the same refinery/in the same program.

The selection of participants, and particularly the lack of involvement of the business side as a key stakeholder, received a mixed perception. Representatives of the business side had rejected the report as a one-sided story while both the contractor and project members from OwnerOrg had accepted it. On the one hand, this led to push-back from one person from the business side. On the other hand, having just the project team's perspective was considered powerful on its own.

On the positive side, the overall atmosphere was characterized through openness and independence (the participants were given the time to really say what they think). The usage of the group support system in the workshop phase was perceived as very powerful. Specific contributing factors were that

- there were no differences in rank influencing who can contribute /no individuals obviously dominating the contributions (e.g., through speaking time as would be expected in an oral discussion)
- the scoring was fast and easy
- the participants were able to work in parallel

As a consequence, the workshop was perceived as collecting a lot of information in a very efficient way.

10.5 Discussion and Conclusions (RefineryCol)

Among the LLCPes studied in this research, RefineryCol was a unique in that the case organization OwnerOrg required projects to collect lessons learned. It was also the only project with a strong conflict between the stakeholders (and participants), leading to the creation of a safe environment for participants as a design concern. On a design level, it was the only process involving interviews, and the only one that considered how lessons learned compared on impact and importance after the topics were analyzed in depth.

The characterization of the lessons learned and the evaluation indicate that LLCP can be considered a partial success: the LLCP actually collected usable lessons learned, and the set of lessons learned covered all major aspects of the project regarding project management (completeness). However, the perception of the quality of the lessons learned was mixed. While the lessons learned were following a discernible structure, this structure was used inconsistently across the lessons learned. This allowed for flexible storylines adapting to the experiences, but made it more difficult for a reader to quickly orient themselves. In addition, not all collected recommendations were actually feasible.

Also, both the evaluation and the characterization of the lessons learned showed that the lessons learned were based predominantly on initial negative experiences, leading to objections from participants. However, some positive experiences (not necessarily from the RefineryProject) were subsumed in the recommendations, and therefore not easily identifiable. Furthermore, the lessons learned did not contain knowledge about the product build in the project but focused on project management, or processes employed by engineers.

Overall, the LLCP was successful in collecting process knowledge (but not product knowledge), and (potentially untried) recommendations aiming to improve future projects. However, the perception of the quality of the lessons learned was mixed, and the set of lessons learned was still biased towards negative lessons learned.

Similar to the other cases, there was a partial match between the task goals of activities and observed outcomes. On a high level, the abstracted LLCP can account for observed intermediary and final outcomes such as the rating results (as outcomes of one workshop activity) and the drafts of the report (as outcomes of the intermediary and post-processing phase; representing the content of the interviews and the workshop phase).

The resulting lessons learned were a result of the interaction of participants, instruments (including the abstracted LLCP), and individuals in supporting roles. Apart from the content of the lessons learned, potential influences relate to the quantity of lessons learned, and their level of detail.

The quantity of lessons learned was a result of the contributions made in the interviewing phase. As participants did not make contributions in such a way that a saturation point for topics or lessons learned was reached, the quantity of lessons learned might have been limited by the number of interviews, and the limited time for each interview (in combination with a time-consuming interviewing strategy that allowed each participant to tell their story). However, there were no indications on explicit boundaries for the quantity of lessons learned (e.g., topics were not explicitly excluded, and there were no limits on how many topics could be explored in an interview).

Several aspects of the abstracted LLCP influenced the level of detail. First, the interviews were set up in such a way that participants actually told their (elaborate) stories in RPID3. Also, the quality assurance and the simulations in the interviews led participants to add details to the actual events, situations, the recommendations, and (potential) consequences. Second, participants were asked to elaborate on the contributions in RPWD1. Last, the (complete) written records of the contributions were analyzed and the results presented in a drafted and final report. As the analysis and writing activities were performed by individuals in supporting roles, this suggest that the relationship between the participants' contributions and the content (including the details) actually presented in the report is mediated by factors associated with activities in the intermediary and post-processing phase. How these factors actually influenced the level detail is a matter for future research (particularly with regard to the methods used for the analysis, and a shared understanding between participants and individuals in supporting roles regarding the contributions).

The intermediary results and the drafted reports had unique characteristics that could not be attributed to the abstracted LLCP. The focus on process knowledge cannot be explained with the guidance provided in the interviews, because the interviews used open-ended questions that allowed for both process and product knowledge. Similarly, the number of positive lessons learned (or rather the lack thereof) may not be influenced by the abstracted LLCP. During the LLCP, positive experiences were stressed as an important basis for lessons learned (through instructions in the interviews and a separate activity in the workshop). However, these interventions had little effect. In this context it is interesting to note that, during the workshop activity, participants had difficulties identifying positive (high-level) outcomes in the project. Also, the topics were, to a large extent, associated with project management, even though project management was not prescribed in the interviews (particularly RPID3), and one participant actually contributed a technical lesson learned.

Chapter 11

TerminationCol: Collecting Lessons Learned for Immediate Reuse

TerminationCol was a guided collaborative LLCP taking place in a multi-campaign project, each campaign with a similar task. It is unique among the LLCPes in this thesis in that its design included a transition towards the usage of collected lessons learned.

11.1 Basic Model (TerminationCol)

Purpose and task goal. The main purpose of TerminationCol was to improve the performance in the next campaign in the TerminationProject. Thus, TerminationCol focused on the improvement of a single *known* campaign very *similar* to the original campaign. In order to achieve this purpose, the task goal of the LLCP was to reflect on the last campaign, and to define actions focusing on the improvement of next year's campaign. The task goal focused on activities of two stakeholders in the project: MarineOrg, and one subcontractor. Remarkably, neither the purpose nor the task goal indicated that the lessons learned might be used beyond the TerminationProject.

Participants. 28 participants associated with six organizations (see Table 11.1 on the following page) attended TerminationCol. Following the scope of the task goal, all but four participants were associated with either MarineOrg or the aforementioned subcontractor. The remaining four participants each represented one additional subcontractor.

There are three points to note about the participants. First, the client organization was not represented at all. Second, the participants were not a homogeneous group: apart from their varying national and organizational affiliations (with MarineOrg and the main subcontractor operating from The Netherlands and Norway, respectively), they also had varying roles in the project. In the end, the group of participants included team leaders of the project. Last, in order to support the purpose of TerminationCol, employees engaged in the previous campaign were expected to continue in the following campaign. These employees were also participants in the LLCP.

Instruments and supporting roles. TerminationCol was supported by an internal facilitator, who also acted as a writer for a report of the LLCP. The role of the facilitator was taken on by the knowledge manager who helped participants in RepositoryCol.

The main instrument was an abstracted LLCP described in the following section (see

Table 11.1: Number of participants per organization (TerminationProject)

Organization	Participants
MarineCoop	14
Main subcontractor	10
Other contractor 1	1
Other contractor 2	1
Other contractor 3	1
Other contractor 4	1
	28

Section 11.2).

The physical tools included software and hardware tools for giving presentations, and 7 paper-based spreadsheets (A1 format) for documenting and sharing contributions with subgroups of participants. Paper-based questionnaires (focusing on the identified themes and topics) were used for collecting contributions that were not shared with the other participants in their raw form.

The environment.

In TerminationCol, the lessons learned were collected in retrospect after completing one campaign in the TerminationProject (see also Section 2.3.1.4 on page 27). As expected, a major influence on the content discussed in TerminationCol was the events in the previous campaign. The content was also influenced by a future event: the following campaign in the TerminationProject (as participants discussed how to deal with issues in order to prevent them in the next campaign, see also purpose of TerminationCol).

Further evidence regarding environmental factors on the LLCP is sparse. TerminationCol was not the first LLCP in the TerminationProject, and experiences with former LLCPes may have influenced the potential participants. Importantly, the intention to collect lessons learned was formed in the environment of TerminationCol, and focused on the prospect of using the outcomes in the next campaign. Another environmental factor was the willingness to work with a project-external facilitator to guide through the LLCP.

Last, an activity prior to the LLCP resulted in an additional challenge for TerminationCol: during the campaign (and thus prior to TerminationCol), the project members collected about 160 detailed technical lessons learned in a spreadsheet. These lessons learned needed to be processed in such a way that they were useful and manageable during the next campaign. On the one hand, it was considered to be insufficient to just select the top 5 lessons learned for implementation in the next campaign. On the other hand, the facilitator considered it a challenge to motivate potential participants to process such a large number of technical lessons learned.

11.2 Lesson Learned Collection Process

TerminationCol consisted of several preparation activities, a main phase, and a post-processing phase for following up on the results of the main phase.

11.2.1 Preparation Phase

With one exception – the selection of ground rules – the potential input categories suggested in Table 5.1 on page 72 could be identified for TerminationCol (see Box 11.1 for specific results). Several of the input categories resulted in content created for or adapted to TerminationCol, suggesting that the associated preparation activities were specifically performed for the process.

It is noteworthy that one preparation activity – the identification of themes and topics – partially addressed the design concerns regarding the large number of detailed technical lessons learned, and reduced the amount of information to be considered in the main phase.

Box 11.1: Input for the main phase in TerminationCol

Items in italics were specifically created for or adapted to TerminationCol. The other items indicate that the input may not have been created specifically for TerminationCol.

Identified themes and topics Prior to the main phase, seven themes were identified for the LLCP. Each theme was associated with an average of four (range: two to six) topics. These themes and topics were a reduction of the topics discussed in the previous campaign and the lessons learned collected prior to the session.

Goal of the process The purpose and task goal were unique to TerminationCol: both focused on the campaigns in the TerminationProject and the task goal targeted lessons learned between MarineOrg and one subcontractor (see also purpose and task goal in Section 11.1 on page 177).

Designed process TerminationCol contained a unique abstracted LLCP. Its uniqueness was reflected in influences from the environment (e.g., the integration of previously collected lessons learned). The abstracted LLCP consisted of a sequence of abstracted activities for the main phase (represented in an agenda), a selection of instruments for performing these activities, and a combination of activities with the interaction settings.

Selected and informed participants The participants were individuals affiliated with MarineOrg and the main sub-contractor. They included individuals who could initiate the implementation of the lessons learned in the following campaign. Some participants had to prepare and give a presentation during the LLCP[a].

Facilitator The facilitator was selected due to her availability in MarineOrg, and her involvement in other lessons learned efforts in the organization.

Location The location for the LLCP was organized prior to the main phase. It required separate tables to support sub-groups in their interaction (see also Section 11.2.2.1 on the following page).

Selected and organized tools The paper-based tools (e.g., the spreadsheets for documenting lessons learned) were each adapted to one of the seven themes, and were therefore organized specifically for TerminationCol. Other tools may have been part of the equipment of the location (see also Section 11.1 on page 177 for an overview).

Prepared instruments for main phase The preparation of specific instruments was associated with outputs from other activities in the preparation phase. For the first set of activities in the main phase, presenters had to prepare their own presentations focusing on the events in the last campaign. Also, techniques such as the aforementioned questionnaire had to be selected beforehand.

[a]There was no data available on who invited the participants, or whether other participants were asked to prepare for the LLCPes

11.2.2 Main Phase

The main phase consisted of an opening phase, a core phase, and a closing phase (see also Figure 11.1). It was performed in a daylong face-to-face workshop.

The opening, core, and closing phase drew upon a shared set of interaction settings presented in the next section.

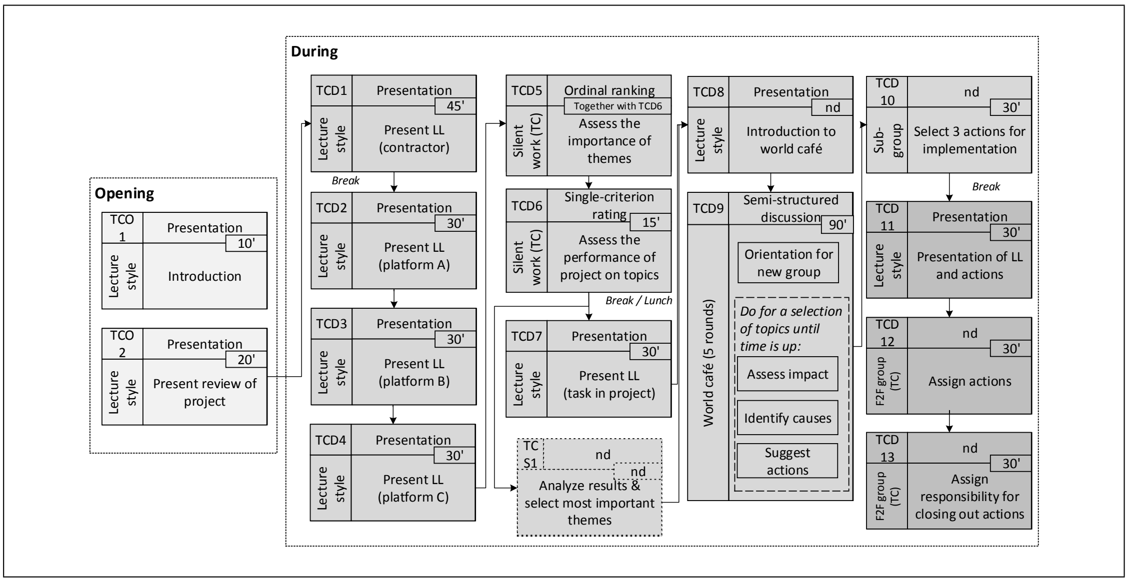

Figure 11.1: Process model for collecting LL (TerminationCol)

11.2.2.1 Interaction settings

The activities in TerminationCol took place in four basic interaction settings (see Table 11.2 on the next page for an overview), and a composite setting, which was internally referred to as the *World Café* [1]

All interaction settings were co-located and synchronous, but varied with regard to who could interact with whom.

Silent work (TC) was characterized by little to no interaction between group members. In *F2F group (TC)*, all participants could interact with each other in a single group, whereas in the *sub-group* setting, participants interacted with a stable[2] subset of participants.

The World Café was based on the sub-group setting. It consisted of $n, n \in \mathbb{N}_{>1}$, moderators, n sub-groups, and n rotations. It was supported by the seating arrangements: initially, each moderator was physically located at a table together with a sub-group, interacting in the sub-groups setting. After a fixed time interval (here: 20 minutes), the sub-groups (without the moderator) rotated to the next moderator (without changing sub-groups), again engaging in the sub-group interaction setting. After n rotations, each participant had had the opportunity to work with every moderator.

The World Café was used in order to handle larger groups (e.g., 20 people). Working on a single lesson learned with a larger group was considered inefficient, unproductive,

[1]The World Café was based on a method of the same of the name (see www.theworldcafe.com/method.html, last accessed: 23/02/2015).

[2]Participants were not expected to dynamically change groups.

difficult to document, and prone to foster social loafing (this is a group phenomenon in which participants reduce their effort or contributions compared to settings in which they work alone, see Nijstad (2009) for an overview), whereas the World Café resulted in a more active participation. However, the World Café had the disadvantage that the moderator was responsible for documenting and facilitating the actual group work.

Table 11.2: Interaction settings in TerminationCol

	Lecture style	Silent work (TC)	(Single) F2F group (TC)	Sub-group
Expression mode (participants)	verbally[a]	in writing	verbally	verbally
Anonymity	no	yes[b]	no	no
Interaction among participants	yes[a]	no	yes	yes
Sub-grouping	no[a]	-	no	yes
Simultaneity	take turns[a]	-	turn taking	turn taking
Relative Location	co-located	co-located	co-located	co-located
Synchronicity	same time	same time	same time	same time

[a] assumed setting based on general co-located presentations

[b] aggregated results were shared with the group in a later activity; these results could not be traced back to individual participants

11.2.2.2 Opening phase

The opening phase focused on introducing the LLCP. This set consisted of two activities (**TCO1** and **TCO2**) These activities used a presentation technique, and were performed in a lecture style. The main input for these activities were presentation materials created during the preparation activities (see Box 11.1 on page 179), and the set of tools used to support presentations (see Box 11.1 on page 179). While there was no further data available on TCO1, **TCO2** continued the opening phase of the session with a review of the last campaign. The presenter provided positive feedback on the campaign and outlined it as a success with regard to two performance indicators for projects, schedule and safety. In addition, the presenter summarized major challenges encountered by each team.

11.2.2.3 Core phase

The core phase consisted of four sets of activities for (a) presenting existing lessons learned, (b) assessing the project performance regarding topics related to these lessons learned, (c) documenting lessons learned and associated actions, and (d) selecting actions for implementation.

Presenting extant lessons learned The opening phase was followed by a sequence of presentation on extant lessons learned, collected prior to the workshop. The configuration and scope of these presentations varied, e.g., **TCD1** focused on results from internal LLCPes and LLCPes with the four subcontractors, whereas **TCD2** to **TCD4** focused on the work performed by four teams in one project location; accordingly, the team leaders took on the role of presenters. In turn, TCD7 focused on a part of the process that performed in a different project location. Similar to the opening phase, all activities used a presentation technique, and were performed in a lecture style. The main input for these activities were presentation materials created during the preparation activities (see Box 11.1 on page 179), and the set of tools used to support presentations (see Box 11.1 on page 179). These presentations followed a similar structure. First, they introduced the presentation, e.g., by outlining the scope of the work performed during the campaign. Second, they summarized a few lessons learned relating to this work. Last, they offered conclusions on what to repeat in the next campaign, or posed discussion points and open issues used during the third set of activities. Particularly the first part of each presentation was used to also provide positive remarks and feedback on the performed work, which indicates that the presenters were attempting to create a positive atmosphere during the workshop.

Assessing the project performance Activities TCD5, TCD6, and TCS1 focused on an assessment of the project performance. The task goal for these activities was to reduce the number of themes to be discussed in the following activities, and to identify key topics for TCD9.

To achieve these two goals, **TCD5** and **TCD6** used techniques for evaluating themes in a questionnaire: ordinal ranking and single criteria rating, respectively. Ordinal ranking is a technique that asks a participant to assign the integers 1 to n (representing the place) to n items based on a criterion with (implied) preference indications, so that an item with a lower place number is preferred or equal to an item with a higher place number. Ties are not allowed, and transitivity applies. An ordinal ranking does not express a degree of preference: the first item is not twice as preferable as the third one (based on Cook and Seiford (1978)). Single-criterion rating is a rating technique (see RCA4 in Section 8.2.3 on page 117) that utilizes one criterion to evaluate all items list of items.

During both activities, interaction between participants was not required. Participants received instructions from the facilitator in the beginning of TCD5. In addition, printouts of the questionnaire (see also Box 11.1 on page 179) repeated the main instructions for TCD5.

For TCD5, the ranking was configured with seven themes (see Table 11.4 on page 185 as the items. Participants were asked to „rank [seven themes] in order of importance for the [next campaign] by assigning numbers from 1 (most important) to 7 (least important) to the themes”. In turn, the single-criterion rating was configured with topics plus the option „other” (organized by the seven themes) as ballot items and a scale from 1 (bad) to 5 (excellent) complemented with the option „don't know”. The importance of a topic for the next campaign served as the criterion. In addition, participants could add a qualitative comment to each topic.

With regard to deficiency prevention, the facilitator employed constraint emphasis (i.e., stating the constraints applicable to an activity, and keeping these constraints visible during the activity Kolfschoten et al. (2011)) by both presenting instructions before the activity, and repeating some constraints (such as the scales and instructions for TCD5) in the questionnaire. In addition, the option „don't know” in TCD6 is a mechanism similar to that used in self-completion questionnaires employed in research contexts (see Section 6.1.5 on page 83), where it can help to reduce measurement errors based on a lack of familiarity or knowledge regarding an item in a questionnaire. Last, the options to add items and to comment on existing ones may have resulted in qualitative data complementing the quantitative data.

In the following supporting activity **TCS1** (which was performed in parallel to TCD7), the votes from TCD5 and TCD6 were used to select the *five worst-performing themes* for further discussion and „to determine the subjects that require the largest improvement". The analysis included determining the average scores per topics. However, there were no further data available on how the voting results were used to determine the themes for the following activities.

The activity set had two major outcomes. First, the number of themes was reduced from seven themes to five themes – a reduction to about 70%. Second, for each topic, a performance score was calculated, and used as input for the following discussions.

Documenting lessons learned and defining actions The following set of activities focused on documenting lessons learned and associated actions. The purpose of these activities was to identify next steps to be taken in the TerminationProject. Starting with **TCD8**, participants were introduced to the World Café (the interaction setting used in TCD9), and to the main task of TCD9.

TCD9 itself was a set of activities in which participants documented the lessons learned. For the World Café (with n = 5), participants were divided into five sub-groups, each sub-group initially working on one of the themes selected in TCS1. The discussions around the themes were moderated by the team leaders of the campaign. The rotations of the World Café continued until each group had discussed each theme.

TCD9 used a semi-structured group discussion as its technique. The main configuration of the technique were the structure – a set of guiding questions (see Box 11.2 on the following page) – and a template[3] (Table 11.3 on the next page) for documenting results from the discussion.

The structure of the lessons learned differed from the one used for documenting lessons learned prior to TerminationCol. While both formats asked for the topic and actions, in TerminationCol, the participants were not asked to document meta-data (e.g., the discipline or phase of the project). Instead, they were asked to document the impact on the project, as well as the root causes.

The tool support for the technique consisted of A1 spreadsheets, one for each theme. These spreadsheets displayed the guiding questions, followed by the aggregated voting results for each topic (which constituted the main input for TCD9), and the template for documenting the lessons learned.

Each sub-group started the discussion with an introduction from a moderator assigned to a theme, who outlined the task in the first round, and, starting with the second round, apprised the participants of the discussion results obtained in previous rounds. In the ensuing discussion, the participants identified the impact a topic had on the project, the root cause for the low score and an action for improving the following campaign.

[3]The guiding questions, the template and the final results did not demarcate the lessons learned. This chapter assumes that one lessons learned was equivalent to a root cause (often combined with an impact and an action) or, if a root cause was not described for a topic, to a pairing of a topic with an action.

Box 11.2: Instructions for eliciting lessons learned in activity TCD9 (TerminationCol)

The following instructions were placed at the top of an A1 sheet of paper used for documenting lessons learned (see also Table 11.3 for the template).

Objective: discuss lowest-scoring topics in small groups to determine actions to improve for next campaign

- **Per Subject**
  - What **impact** did it have on the project? (Operational/Safety)
  - What are the root causes for low score?
  - Developing an **action** to improve next year
    - *Specific, Measurable, Achievable, Realistic, Time constrained*

Table 11.3: Template used to document lessons learned in activity TCD9 (TerminationCol)

Topic	Impact	Root Causes	Action for 2012

In order to prevent deficiencies, the facilitator applied a constraint emphasis by explaining instructions prior to the group discussions and keeping these instructions visible on the spreadsheet during TCD9. The instructions also clearly stated quality criteria for the actions (see Box 11.2). Furthermore, the template itself has the potential to prevent deficiencies, as incomplete lessons could easily be identified (see also Kolfschoten et al. (2011)).

Regarding deficiency discovery and fixing, the World Café led to a peer review mechanism. Subsequent sub-groups reviewed the lessons learned documented in previous rounds.

Overall, the intermediary results showed 40 lessons learned as the output of this activity (see Table 11.4 on the facing page for the results per theme). Not every lesson learned was completely documented. For example, the theme communication contained four lessons without impact, and two of those without root cause as well. Nevertheless, with the exception of one lesson that seemed to be unfinished, all lessons learned contained actions for the next campaign. Thus, the deficiency prevention was met with limited success regarding completeness of documenting a lesson learned.

The relationships between themes, topics, root causes, and actions led to a layered structure: each theme had several topics; one topic could have several lessons learned. A comparison of key words in the topic section of a lesson learned and the association of topics with themes (based on the configuration of TCD6) provided more detailed insights. First, one topic could be associated with several themes. Second, one lesson learned could be associated with several topics. Thus, while themes, topics, and lessons learned form a layered structure, this structure is not a tree structure.

Selecting actions for implementation After five rotations in TCD9, the last set of activities focused on the transition into the usage of the collected lessons learned in the next campaign.

TCD10 utilized the documented lessons learned from the previous activity, and asked the sub-groups to select the three most important actions for their theme. Due to the rotational scheme, this selection was performed by the sub-groups who had first discussed a theme.

Comparing the final lessons learned with intermediary results revealed that participants went beyond the instructions summarized in the report. During TCD10 (and possibly TCD9) they did not just generate first answers to the questions posed in TCD9, and select actions, but also improved the quality of the final results. For example, topics became more specific by adding sub-headings; actions were rephrased (e.g., the final actions used verbs to describe what to do, whereas intermediary versions also stated states instead of things to do), and examples were added to the actions. In addition, content was reorganized (e.g., one topic label was moved to serve as a header in the action field), and lessons learned addressing several aspects of an issue were merged into one lesson learned.

Furthermore, an analysis of the final lessons learned showed that the participants created more fine-grained structures than the one suggested by the template and the guiding questions. Some topics contained two headers: a general one referring to the topic mentioned in the survey, and a more specific one referring to the lesson learned. In addition, some actions were structured by adding sub-tasks.

All in all, participants selected 20 lessons learned for implementation in the next campaign (a 50% reduction), the total word count dropped from 1059 to 551 (a reduction by 48%; see Table E.8 on page 286 for details on the word counts). However, as shown in Table 11.4, two sub-groups (working on the themes safety and team) did not follow the instructions to select three actions. Instead, they selected three topics to be addressed in the next campaign.

Table 11.4: Quantitative development of LL – contrasting TCD9 and TCD10

Theme	# LL after TCD9	# LL after TCD10	% Selected LL
Safety	10	4	40
Engineering	8	3	38
Team	7	7	100
Communication	9	3	33
Project execution	6	3	50
	40	**20**	**50**

11.2.2.4 Closing phase

The closing phase focused on moving towards using the collected lessons learned in the TerminationProject. The participants switched to the lecture style interaction setting and presented selected actions and their context to all participants (**TCD11**). As all participants (with the exception of the participants serving as moderators) had contributed to these lessons learned in TCD9, the presentations were rather brief.

In **TCD12**, all actions except one were assigned to participants. The actions were mainly assigned to participants from MarineOrg and the main contractor, often with joint responsibility (see Table 11.5 for detailed results). 75% (15 out of 20) of the lessons learned were assigned to at least one participant acting as a moderator in TCD9, though only 33% (5 out of 15) of those actions were assigned to participants who had moderated the associated theme. Overall, a participant's organizational affiliation and role in the next campaign seemed important factors for the assignment of actions to participants.

Last, in **TCD13**, two participants were selected to close out all selected actions. In practice, their task entailed monitoring the progress of the implementation of actions (and chasing participants to implement them) after the workshop[4].

Table 11.5: Number of actions assigned per organization

Theme	MarineOrg only	Main contractor only	Second contractor only	Joint responsibility MarineOrg and main contractor
Safety	1	2	0	1
Engineering	2	1	0	0
Team	2	3	1	1
Communication	1	0	0	2
Project Execution	1	0	0	1
	7	**6**	**1**	**5**

11.2.3 Post-processing Phase

The facilitator, acting as a writer, created a report of the workshop summarizing and integrating the designed process, the presentations, voting results, and the paper-based intermediary and final lessons learned.

11.3 Characterizing the Collected Lessons Learned (TerminationCol)

The set of lessons learned. Overall, TerminationCol resulted in 20 lessons learned. All lessons learned focused on the process, and not on the product of the project. 16 of these were *negative* (see Table 11.6 on the facing page). The lessons learned were embedded in a report on the LLCP that also summarized the process and intermediary results of the process, and provided notes on the presentations given by the participants.

Structure of the lessons learned. The lessons learned generally followed the structure prescribed in Table 11.3 on page 184, though some lessons learned were missing the impact or root causes. Detailed observations regarding the lessons learned are summarized in Table 11.7 on the facing page. It is noteworthy that the lessons learned did not contain detailed descriptions of what happened. Only the impact summarized

[4]The knowledge manager considered this activity to be crucial for the overall success of the lessons learned processes in the TerminationProject.

some high-level states experienced in the project. Even though for some topics, a background was outlined in the presentations given by the participants, the report did not link the lessons learned to the notes of the presentations. Overall, this might make it difficult for an independent reader to understand the context of the lessons learned.

Recommendations and actions. There was no explicit general learnings, i.e., statements of what should be done differently in a similar context in MarineOrg, or in similar future projects. Rather, the actions took the place of these learnings by explicitly describing which steps to take in the next campaign. Other usage scenarios for the learnings in the project were not addressed.

All actions were described using the imperative, and none of the actions was reactive. Actions could outline what kind of alternative to develop to address the identified root causes (e.g., developing a new labeling system for a hazardous substance), or they could describe (abstract) solutions (e.g., share a particular kind of existing information). One action suggested further investigating a problem.

Table 11.6: Number of positive and negative LL per theme (after TCD12)

Theme	Negative LL	Positive LL	Other LL
Safety	3	0	1
Engineering	3	0	0
Team	5	0	2 (no cause or impact)
Communication	3	0	0
Project Execution	2	0	1
	16	**0**	**4**

Table 11.7: Content of drafted lessons learned (TerminationCol)

LL format used in TCD9	Timeline (referring to)	Content
Topic		Stated a main topic (typically containing vocabulary from the questionnaire), optionally followed by a subtopic
Impact	last campaign	Effects on the project described with keywords. Both high level effects (e.g., “delays”, “safety”) and more detailed effects (e.g., “postponed risk management”) were listed. The impact mainly referred to schedule and planning, safety, and communication.
Root causes	last campaign	Perceived causes for the experiences in the project typically described on a general level using keywords or (rarely) the present tense. The causes referred to planning, methods and procedures used in the project, resources (both employees and equipment), and communication.
Actions for 2012	future campaign	One or more actions to be implemented in the next campaign. They typically addressed the identified root causes (e.g., the root cause “bad signs/ labels” was addressed by an action to develop a labelling system).
Assigned to		Organization (MarineOrg or subcontractor) and employee responsible for the actions.

11.4 Evaluation

The evaluation for TerminationCol focused on an interview with the knowledge manager who provided insights into the usage of the collected lessons learned, and the continued usage of instruments. Participants (or other employees) were not available for an assessment of the collected lessons learned.

Usage of the collected LL. TerminationCol produced 20 structured lessons learned. As such, the LLCP was able to fulfill the task goals.

Of these lessons learned, all but one were used in the project (by implementing the associated actions). The knowledge manager attributed the successful usage of the lessons learned to a continued monitoring (and chasing) of the implementation efforts (see TCD13). Also, due to the division of the TerminationProject into phases with similar undertakings and a continuation of personnel, the implementation of actions was in the project team's self-interest.

The one lesson learned that was not used did not seem to represent a serious enough problem to justify taking actions. However, the symptoms re-occurred in the next phase in the project (which put the lesson learned on the agenda for the next LLCP in the TerminationProject), suggesting that an (informal) judgment on the severity of problem had been be inaccurate.

Interestingly, the interviewee also indicated that the lessons learned might be used to foster change in the subcontractor, because of their long-term relationship ($_{10}$ years). The outcomes of such usage of lessons learned are not known, though.

Continued usage of instruments. The abstracted LLCP (or a variation thereof) was continued to be used in the following phase of the TerminationProject.

Also, two instruments encountered in the context of TerminationCol were reused in other lessons learned processes. First, the „monitoring and chasing" approach (see above) was used to foster the implementation of actions on an organizational level. Second, the interaction setting World Caf'{e} (described in Section 11.2.2.1 on page 180) together with the associated documentation of lessons learned through table heads was used as a design component for managing large groups, even in other abstracted LLCP (e.g., in combination with the one observed in DepartmentCol, see Chapter 9 on page 127).

11.5 Discussion and Conclusions (TerminationCol)

This chapter presented a detailed analysis of TerminationCol based on the basic and extended model of LLCPes. The abstracted process allowed participants to collaborate, and to share their experiences on the project without documenting the whole discussion. While the resulting lessons learned identified root causes and impact, events and expectations were not documented. In this research, TerminationCol was the only process using moderators to facilitate oral discussions of the lessons learned. Insights into the preparation activities (Section 11.2.1 on page 179) showed that the process was intentionally designed for larger groups, using a combination of the interaction setting World Café with the moderator concept. This resulted in a scalable process, in which several themes were addressed.

The evaluation of the LLCP and the characterization of the collected lessons learned indicated that the process can be considered a success in the sense that usable and useful negative lessons learned were created in TerminationCol. Similar to DeepwaterCol, only negative lessons learned were collected. However, even though the resulting lessons learned were well-structured, their overall brevity and lack of context could make it difficult for a reader unfamiliar with the project to find out what to do in order to prevent mistakes from reoccurring, and to find out what had happened on the project. The latter may result in a limited understanding of the actual problem as well. Furthermore, this lack of documentation indicates that the use of the lessons learned in the subsequent campaign relied only partially on the documented lessons. The users of the actions had been participants in TerminationCol. Thus, they did not just acquire documented lessons learned, but could also have gained implicit knowledge on the developed actions.

Overall, TerminationCol was successful in creating negative lessons learned for the subsequent campaign. It was unsuccessful in creating positive lessons learned. These lessons were usable by the participants, but their usability for readers unfamiliar with the project may be limited.

In the following, this section explores the transferability of the abstracted process to similar lessons learned collection opportunities, starting with the question to what extent the abstracted process can account for characteristics of the collected lessons learned. Similar to DeepwaterCol, TerminationCol showed some relationships between key characteristics of the collected lessons learned and aspects of the abstracted process. First, the template and guiding questions (see TCD9 in Section 11.2.2.3 on page 183) matched the *structure* of the collected lessons learned. The lessons learned documented prior to TerminationCol did not use the same structure. Therefore, it is reasonable to assume that the structure provided during TerminationCol was instrumental in shaping the structure of the final lessons learned.

Furthermore, the selection of themes (see Section 11.2.2.3 on page 182) and the selection of actions (see Section 11.2.2.3 on page 184) were activities influencing the *quantity* of the final lessons learned. These activities had an effect similar to DeepwaterCol and DepartmentCol in that participants did not have a discussion with excluded themes or topics as the starting point. However, considering that one topic could be associated with multiple themes, this does not preclude the possibility that some of the filtered out themes were addressed in the final results. Thus, the assessment of the project performance and subsequent selection of themes may also have influenced the *themes* and topics discussed in the LLCP, but further research involving an assessment by participants is needed to understand the actual impact of the project assessment on the discussed topics.

Overall, the abstracted process may have shaped key characteristics (structure, quantity, and the distribution of lessons learned across themes) of the collected lessons learned.

When transferring the abstracted LLCP to similar collection situations, these outcome characteristics may therefore reoccur. However, some characteristics of the final lessons learned could not be attributed to the abstracted process. For example, the documented lessons learned were the briefest[5] presented in this thesis (nevertheless, they were also the only ones systematically and extensively used). This brevity could have

[5] Add table supporting this notion

been caused by the way of documenting insights during and after the main phase. TerminationCol was the only observed process in which oral discussions were not recorded with an audio recorder. As a consequence, the writer had no additional data for extending the notes during the post-processing phase. However, as detailed observations on quality assurance and actual instructions used during TerminationCol were not available for this research, it is uncertain whether participants were actually asked to discuss details during the LLCP. Also, the moderators' and participants' expectations regarding the use of lessons learned may have influenced the level of detail and extent of documentation: if the participants knew that they would be the ones using the lessons learned, an extensive documentation of root causes and impact might have been considered inefficient. Further research is needed to understand whether participants using an abstract version of TerminationCol would consistently document such brief lessons learned, and which aspects of TerminationCol would need to be changed to obtain a more detailed documentation.

Second, similar to DeepwaterCol, it remains an interesting question whether, with a different task goal, TerminationCol could be used to extensively document product knowledge as well. Third, the selection criteria for themes in TCS1 indicated that participants were implicitly asked to collect negative lessons learned. Last, it is noteworthy that the drafted lessons learned did not suggest reactive or monitoring actions (see also Section 3.5 on page 43), even though the abstracted process did not limit suggestions to preventative actions.

The abstracted LLCP cannot explain the types of actions created in the process. Also, further research is needed to understand to what extent the focus on process knowledge and negative lessons learned, and the brevity of the lessons learned was affected by the abstracted process.

Thus, when transferring the abstracted process to other opportunities for collecting lessons learned, these outcome characteristics may not reoccur. The reoccurrence of outcome characteristics does not just depend on the abstracted process, but also on additional factors. Chapter 4 on page 45 outlined factors associated with the participants and the environment. Furthermore, as it was not feasible to directly observe TerminationCol, the description of the abstracted process is limited, affecting, e.g., the fine-grained questioning for developing the lessons learned, or aspects of quality assurance.

Consequently, the limited availability of data may have resulted in an incomplete description of the LLCP, which may pose a barrier to reproducing outcome characteristics.

DeepwaterCol I & II utilized a facilitator to restrict participants to behavior in line with the abstracted LLCP. In TerminationCol, the facilitator still restricted and guided the participants' behavior. However, the moderators were primarily responsible for restricting and guiding participants during the collection of lessons learned, and during the selection of actions. In general, the abstracted process seemed to have been followed as intermediary outputs matched the task goals. However, some deviations for the activities involving moderators should be highlighted: during the collection of lessons learned, some lessons learned were incompletely documented (also resulting in incomplete final lessons learned). Similarly, not every sub-group followed the instruction to select three actions during the selection of actions.

With a few exceptions the abstracted LLCP can account for the intermediary *outcomes observed in the process.*

Both behavioral occurrences indicate that the moderators modified the abstracted process. If moderators allow for more deviations from an abstracted process than a facilitator, this may influence outcome characteristics of the transferred abstracted process in unpredictable ways. However, it remains a matter for future research to investigate whether untrained moderators offer a less restrictive application of abstracted activities than facilitators.

Guidance and restrictiveness provided by the facilitator, the moderators and the written instructions may have mediated the effects of the abstracted LLCP.

Unlike the other LLCPes observed in this thesis, TerminationCol contained two activities that shaped the transition to using the lessons learned. In one activity, the responsibilities for actually implementing the actions were assigned to participants. In the other activity, two participants received the responsibility to actually monitor the usage of the lessons learned. The knowledge manager considered both activities essential for the successful usage of the collected lessons learned. Considering that the responsibilities for the actions were distributed to participants representing MarineOrg and its main contractor, TerminationCol may have produced an additional outcome: a commitment of participants (and stakeholders) towards implementing actions developed in the LLCP.

The successful use of lessons learned may have been dependent on (a) informal knowledge sharing between participants in TerminationCol, (b) creating commitment towards the developed actions, and (c) monitoring activities prepared in TerminationCol.

As a consequence, there are limitations to combining the abstracted LLCP with the usage scenarios discussed in Chapter 3 on page 33. TerminationCol showed that the lessons learned can be used in similar *known* future projects. However, in order to successfully use the collected lessons learned, users need to be involved in the process. If a future *project* is not planned yet, or unknown, this requirement cannot be fulfilled. In contrast, the usage of lessons learned on an organizational level offers more opportunities to involve individuals responsible for implementing the lessons learned. However, it remains a matter for future research to investigate how the abstracted process needs to be changed in order to accommodate the use of lessons learned on an organizational level. As a minimum, the task goal and participant selection need to be adapted to focus on an organizational level.

Chapter 12

InnovCol: Collecting Lessons Learned at a Project Milestone

InnovCol was a facilitated collaborative LLCP that took place after the FEED phase in an energy project. It was the only LLCP that utilized three *distributed* sessions supported by a *GSS*.

12.1 Results for the Basic Model (InnovCol)

The environment. The lessons learned were collected in retrospect after the FEED phase of the InnovProject. The physical environment of the LLCP varied, depending on the choice of (and opportunity afforded to) participants.

Several factors in the environment may have influenced InnovCol. First, the existence of the LLCP was due to arrangements made prior to the start of InnovProject. More precisely, one of the organizations funding the project required a LLCP.

The most important potential influence of the environment on participants stems from the project content, and its perception. The project aimed to demonstrate the technological and economic feasibility of a new technology. As such, the project was perceived as novel and associated with uncommon challenges. Furthermore, the LLCP was conducted in retrospect, which can potentially lead to memory issues (see also the challenge on encoding and accessibility of memories, challenge **Part1** on page 63). Furthermore, three other LLCPes in the same project were performed prior to InnovCol in approximately the same time period, and offered some participants an opportunity to gain experiences with similar LLCPes.

Last, there were several factors in the environment that influenced the selection of *instruments* for InnovCol. One factor was the willingness to provide an external facilitator and tools to support the design and execution of the LLCPes in this project. In addition, the abstracted processes of the prior LLCPes were similar to the abstracted process employed in InnovCol, and experiences with these LLCPes lead to the design of InnovCol. Similarities and differences with these previous LLCPes are pointed out in the footnotes in the following section.

Participants. The participants can be characterized as mainly male and young, with a higher education and a technical background (see also Section 12.4 on page 201 for the survey results on participants). The participants for the LLCP included the project manager of the project. Not all stakeholders in the project were represented in the LLCP. For example, contractors of the project were intentionally not included (see also Box 12.1 on page 196).

The participants were geographically distributed (including Germany and the Netherlands), which would result in substantial travel time and a potential for scheduling conflicts for a co-located LLCP. Regarding previous experiences with LLCPes, some participants had participated in the LLCPes conducted prior to InnovCol.

Purpose and task goal. The task goal for InnovCol was to create a record of the most important *technical* lessons learned from experts in the project, while maintaining confidentiality. The concept of technical lessons learned was further explained as lessons learned concerning the technical development process, and issues regarding specific technical products and equipment. There are two things to note here. First, the task emphasized the particularities of InnovCol. Second, it indicates that InnovCol does not aim to collect *all* lessons learned.

The LLCP served several purposes: highlighting fields for future knowledge selling, and sharing lessons learned with the mother companies (as the potential users of the lessons), with future projects using similar technology, and with participants. The resulting lessons learned report should also demonstrate the fulfillment of requirements posed by one of the organizations funding the project. Furthermore, the report aimed to demonstrate that the project itself could continue successfully. Thus, InnovCol aimed not just to influence its environment by sharing knowledge, but also to influence future directions of InnovProject in a positive way.

Instruments and supporting roles. InnovCol was supported by an external facilitator, and writers. The role of the facilitator was taken on by a researcher with extensive experience as a facilitator, but little experience in LLCPes.

The main instrument was an abstracted LLCP that was adapted to the particular task goals of InnovCol (see Section 12.2 for details).

The main software application was a GSS. It was used to capture the participants' contributions. For some activities in the LLCP, it was also used to share these contributions, but not the identity of the contributing participant, with the whole group. Additional software and hardware tools supported sending and receiving emails, and giving presentations. Last, electronic spreadsheets were used by the facilitator in supporting activities.

These LLCPes used facilitated, collaborative LLCPes to collect lessons learned regarding stakeholder management, process, and communication, respectively. The focus of InnovProject on the technological aspects of the project complemented these three themes, suggesting a pre-selection of themes[1] in the environment, and consequently an (indirect) influence of the environment on the task.

12.2 Lesson Learned Collection Process

InnovCol consisted of several preparation activities, a main phase (see Figure 12.1 on the facing page) with four activities for introducing, collecting, and assessing lessons

[1] It is debatable whether the pre-selection of themes was an activity in the environment or in the preparation phase of InnovCol. Activities preparing all four LLCPes were considered shared preparation activities.

learned, and a post-processing phase with an activity for creating a report out of the workshop results.

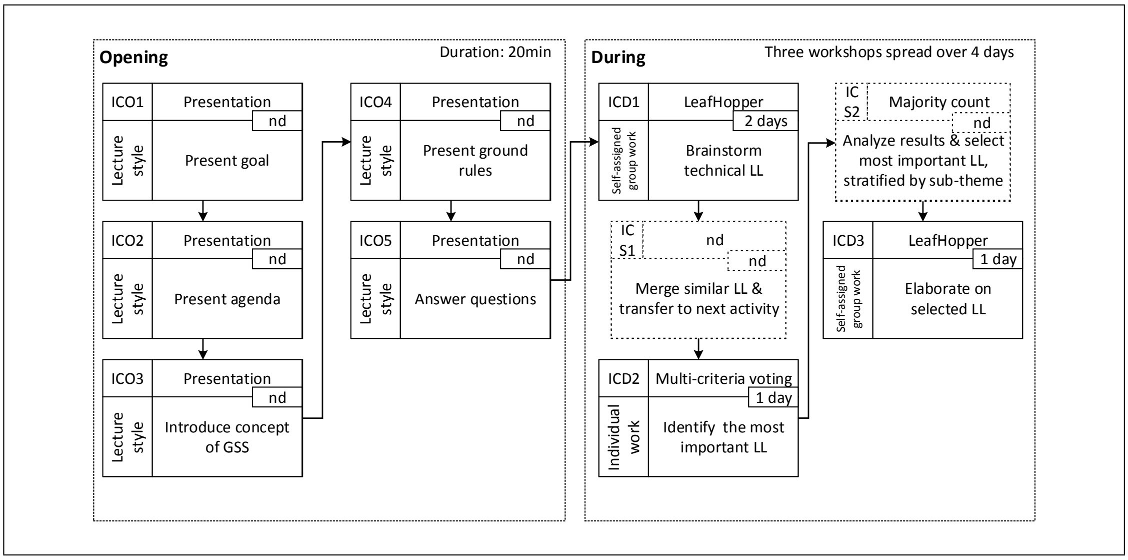

Figure 12.1: Process model for collecting LL (InnovCol)

12.2.1 Preparation Phase

In general, the potential input categories suggested in Table 5.1 on page 72 could be identified for InnovCol. Only a subset of these input categories were specifically created for or adapted to InnovCol (see Box 12.1 for an overview). The particular use of sub-themes in the LLCP, and the design of the abstracted process were created for or adapted to InnovCol, for example. However, the facilitator and the GSS were not unique to InnovCol – their selection was an input used for all four LLCPes in the project.

Box 12.1: Input for the main phase in InnovCol

Items in italics were specifically created for or adapted to InnovCol. The other items indicate that the input may not have been created specifically for this case.

Identified themes and sub-themes Prior to InnovCol, three themes for LLCPes in the InnovProject were identified. One of them – the technical theme – formed the basis for InnovCol. It was further divided into five sub-themes (based on a division of the structure of the installation, and complemented with the categories 'interfaces' and 'other'). Each sub-theme was complemented with a list of keywords.

Goal of the process The purpose and task goal of InnovCol seemed to follow the same pattern observed in the DeepwaterProject: a purpose was defined for all three LLCP (that took place at the same milestone in the project), while the task goals of these LLCPes varied regarding the covered theme (see Section 12.1 on page 193 for an overview of the purpose and task goal identified ex post).

Designed process The designed abstracted LLCP used in InnovCol was an adaptation of the LLCPes used in the InnovProject prior to InnovCol. The key adaptation was in the interaction setting, which offered participants the opportunity to work asynchronously and in a distributed manner during the LLCP. The abstracted process entailed a sequence of abstracted activities for the main phase and an agenda (outlining a timeline, communication channel, and tasks for each activity). Abstract activities throughout the process were adapted to the modified interaction setting (see footnotes in the following section for details).

Selected and informed participants The selection criteria for participants were their expertise and association with InnovOrg (contractors were excluded from the LLCP). The participants included individuals involved in project management, funding management, and engineering[a]. They were invited to the LLCP with a letter from the board of directors.

Selected ground rules The ground rules for InnovCol are listed in Box 12.2 on page 198. In general, they outlined group norms and values during the main phase. With the exception of the last item, they matched the ground rules used in the prior LLCPes in InnovOrg. This last item accounted for the asynchronous interaction by asking participants to come back to the discussion several times.

Facilitator The same facilitator moderated all four LLCPes in the InnovProject. For her selection as a facilitator, her network in the InnovProject played a role

Location Participants were free to choose the location from which they wanted to work during the LLCPes. Their options included, among others, working from their desk or (as a self-organized group) from meeting rooms. The introduction phase was incorporated into a staff meeting, and therefore used its location and general setup.

Selected and organized tools The main tools (e.g., tools for giving presentations, the GSS) used in InnovCol were also used in the other LLCPes in InnovProject, and therefore not unique to InnovCol.

Prepare instruments for main phase The preparation of instruments used outputs from the various activities in the preparation phase. It entailed the creation of slides used in the opening phase (see Section 12.2.2.2 on the facing page). In addition, the facilitator prepared and configured the GSS with activity descriptions and sub-themes (the latter being unique to InnovCol).

[a] This summary is based on the positions respondents stated in the survey, see Section 12.4.1 on page 201 for further details.

12.2.2 Main Phase

The main phase of InnovCol consisted of three sessions (plus an opening session). By using flexible interaction settings, participants could decide when they wanted to contribute, and how they wanted to interact with other participants.

12.2.2.1 Interaction settings

InnovCol had five different interaction settings (see Table 12.1 on the next page for an overview). The *lecture style* was the only co-located, synchronous interaction setting (actually taking place during a staff meeting).

The *self-assigned group work* and the *silent work* (IC) were interaction settings enabled by the GSS. In principle, every participant could interact with every other participant during the self-assigned group work. In contrast, participants worked on their own during the silent work – interaction between the participants was not required.

Both interaction settings entailed two variations. These variations differed only with regard to synchronicity. Version 1 took place synchronously. Participation was optional. Version 2 allowed participants to contribute asynchronously. In both versions, participants could work in a distributed manner. Participation in either version was optional as long as participants made their contributions and quality constraints were met (see following sections). Overall, this setup allowed participants to contribute asynchronously from distributed locations.

These interaction settings were selected in order to accommodate the participants' geographical distribution. Due to increased travel time and resulting scheduling conflicts, it was difficult to arrange a co-located or synchronous settings for collecting lessons learned. In addition, participants of the first three LLCPes provided the feedback that there should have been more time allocated for the LLCP. Allowing (but not enforcing) distributed locations was expected to reduce travel time, and, consequently, to increase the time that could be spend on the actual LLCP. The asynchronous way of interacting was added to address remaining scheduling conflicts.

Both interaction settings were conducted anonymously. The facilitator chose anonymity in order to promote openness, and to reduce barriers. However, considering that the participants' technical expertise varied, and participants knew each other, not every participant could hide his or her identity. Regarding the expression mode, participants contributed to the lessons learned mainly in writing, though oral sharing of contributions was possible in the synchronous, co-located versions of the interaction settings.

In addition, both interaction settings limited what participants could observe about each other. Non-verbal cues associated with face to face interactions (e.g., body language) were not present in these interaction settings (though, again, exceptions might have existed for the synchronous, co-located versions of the interaction settings).

Table 12.1: Interaction settings in InnovCol

	Lecture style	Self-assigned group work	Silent work (IC)
Expression mode (participants)	verbally[a]	verbally	in writing
Anonymity	no	yes	yes
Interaction among participants	yes[a]	yes	no
Sub-grouping	no[a]	yes[b]	-
Simultaneity	turn taking[a]	simultaneous	-
Relative Location	co-located[a]	mixed	mixed
Synchronicity version 1	same time	same time	same time
Synchronicity version 2		asynchronously	asynchronously

[a]assumed setting based on general co-located presentations

[b]self-organized, dynamic forming and changing of sub-groups based on themes and a participant's expertise.

12.2.2.2 Opening phase

The opening phase in InnovCol took place during a staff meeting. It consisted of five activities (**ICO1** to **ICO5**) using a presentation technique and the lecture style interaction setting. The activities were performed with the facilitator and session owner as *presenters*, and participants as the audience. The main input were slides created during the preparation activities (see Box 12.1 on the facing page), and the set of tools to support presentations (see Section 12.1 on page 193). During the activities participants were informed verbally and in writing about the particularities of the following phase in the process: its purpose (see Section 12.1 on page 193 for details), task goal, agenda (including times when they could contribute asynchronously), the use of a GSS, and ground rules (on attitude and behavioral norms, see Box 12.2 on the next page), and to answer the participants' questions. In particular, the presented task was phrased as „*Capture and storage*[2] of the most important '**technical** lessons learned' from InnovOrg". This emphasis highlights various constraints that apply to InnovCol. It sets the focus to technical lessons learned (as opposed to, e.g., a focus on lessons learned on project management), limits lessons learned to InnovOrg (learnings regarding the mother organizations of the joint venture are excluded), and scopes the task of the LLCP to „capture and store" (participants are thus not actively looking for opportunities to reuse a lesson learned. In general, Kolfschoten et al. (2011) suggested that the emphasis of constraints is a modifier for deficiency prevention. In this LLCP it therefore had the potential to prevent deficiencies in the participants' understanding of the task – both in the opening and in the *following* phase.

Box 12.2: Ground rules (InnovCol)

Group Norms and Values

- Be open for different perspectives
- Respond with arguments
- Read to listen to others
- Formulate precisely
- Come back to the discussion several times to react/respond/comment

12.2.2.3 Core phase

As indicated in Figure 12.1 on page 195, the task of the following activity was to brainstorm an initial set of lessons learned (**ICD1**). This activity utilized the technique LeafHopper (see Appendix C on page 263), was supported by the GSS as the main tool, and took place as self-assigned group work. It was planned for one hour in the synchronous version, followed by about two days in the asynchronous one.

The technique was configured with written instructions resulting from the preparation activities. These instructions consisted of a main prompt outlining and scoping the task of the LLCP, and an example topic that illustrated how to operate the GSS in order to collect initial lessons learned. The main prompt asked for both process and product knowledge. In the prompt, a reference to best practices for later projects implied that positive lessons learned were part of the process[3]. Apart from these instructions, the sub-themes were part of the configuration, serving as topics for the LeafHopper. The keywords for each per sub-theme were listed as cues after their sub-theme.

During the activity, participants entered short main contributions (the instructions suggested these should be the lessons learned) to each sub-theme, commented on these main contributions, and reacted to comments[4]. Main contributions and comments could not be edited after posting. Altogether, they contributed 52 lessons learned (see also Table E.11 on page 291) with 170 comments.

[2]This part was actually displayed in red, not in italics.

[3]In the LLCPes prior to InnovProject, the instructions explicitly asked for positive lessons learned.

[4]Some participants protested when the system was shut down prior to the announced time, indicating that they actually used the asynchronous version of the interaction setting. However, it is not quite clear whether this behavior occurred during all three activities with the asynchronous option.

In general, the participants followed the structure of the example, with titles for lessons learned, problem statements, or recommendations as the main contribution, and a discussion and elaboration of these in the comments. However, not all main contributions can be considered lessons learned. They also contained questions and instructions (e.g., „Were there any experiences/REX about large [technical components]?").

The comments contained both content relating to the lesson learned, and questions that participants (and probably the session owner, see below) asked about these lessons (see Box 12.3 and Table E.10 on page 291 for details). Some of these questions addressed quality aspects of lessons learned, e.g., by asking for more specific details, or for additional information improving the understanding of problem. Other questions were concerned with understanding consequences of events for the next phase in the project (and therefore primarily targeted InnovProject and not other projects). Overall, this activity resulted in initial contributions following the instructions, as well as some contributions deviating from these instructions.

There were several aspects in the abstracted activity with the potential to discover deficiencies. First, the written form of the main prompt and the sub-themes clearly stated constraints and kept them visible during the activity. Following Kolfschoten et al. (2011), this pattern fits a constraint emphasis. Furthermore, anonymity can create a safe environment for sharing information and offering critique, and help to separate an idea from its author (Valacich et al., 1992), which may have resulted in a more open discussion.

There are two additional candidates for deficiency prevention that are not mentioned in literature. First, the session owner was available for questions and clarifications during the synchronous part.

Second, the example lesson learned was not just a written instruction, but allowed participants to interactively train on the tool (potentially leading to trial and error learning).

Regarding deficiency discovery and fixing, the session owner monitored the coverage of each sub-theme for completeness, and prompted selected participants to make additional contributions (see also Kolfschoten et al. (2011) on input monitoring).

Following ICD1, the facilitator merged[5] similar lessons learned (with the help of the session owner) in a supporting activity ICS1.

Box 12.3: Types of questions (InnovCol)

Guiding questions were directed at

- Facts
- Identifying challenges /issues (focused on past, present, and future!)
- Understanding problems
- Analysis of problems (e.g., targeting causes)
- Addressing issues (preventing or avoiding, reducing, living with it)
- Understanding the technical design (e.g., how does the design consider [specific issue])
- Understanding the consequences for operating the [designed installation]

[5] In the LLCPes prior to InnovProject, the merging was done with the group.

- Understanding how an activity during the project was done

The next activity (**ICD2**) asked participants (in writing) to prioritize the resulting lessons learned utilizing a multi-criteria rating technique, which was supported by the GSS. This technique was configured with the lessons learned as ballot items[6] (still organized by sub-theme), a scale from 1 (low) to 5(high), and two criteria[7] on which to vote (the impact of a lesson learned on the project and the likeliness of reoccurrence in future projects). During this activity, interaction between participants was not required.

With regard to deficiency prevention, the multi-criteria rating technique employed mechanisms similar to those used in self-completion surveys for improving validity (see Section 6.1.5 on page 83). For example, participants were allowed to rate a selection of items – covering all items was not required. Participants actually used the option to not rate items (the number of ratings per lesson learned on both scales varied between 8 and 13, with a median of 11). Thus, similar to self-completion surveys, the option to not assess an item had the potential to prevent that participants rated items which they did not understand, or for which they did not consider themselves an expert, thus improving the validity of the rating. Another mechanism with the potential to prevent (some deficiencies) employed in ICD2 was anonymity. In a research context, the anonymity of a survey and the absence of an interviewer can result in more honest answers (including criticism), as participants are less likely to answer in a way that is considered desirable by other participants (see also Section 6.1.5 on page 83, and (Valacich et al., 1992)).

In the following supporting activity **ICS2**, the ratings from ICD2 were analyzed, and 13 main contributions were transferred to activity ICD3 (see also Table E.11 on page 291). The results of the analysis were obtained by first calculating the average score for each topic on each criterion. Next, two lessons learned per sub-theme were selected - based on the highest average impact in a sub-theme. Last, another three lessons were selected based on the highest average impact of all remaining lessons learned (with likelihood of reoccurrence as a secondary criterion).

Originally, the facilitator intended to select lessons learned based on the highest average impact among all lessons learned, independent of the sub-themes. However, participants asked for a change in the technique, as it became apparent that some sub-themes would not have been covered otherwise. All in all, this indicates that this technique was adapted during the main phase of the process.

ICD3 used the 14 lessons learned from the previous activity, and asked participants (in writing) to „elaborate on key lessons" in the main prompt. Similar to ICD1, this activity utilized the LeafHopper technique, and was supported by the GSS. Participants performed this activity as self-assigned group work, first for one hour in the synchronous version, and then for about one day in the asynchronous one. The written instructions served as a form of deficiency prevention (whether other quality assurance mechanisms outlined in ICD1 were continued in this activity is unknown). In contrast to ICD1, the LeafHopper was configured with the lessons learned as topics; the sub-themes and associated cues were no longer used. The comments of a lesson were transformed into main contributions for that lesson, and a second layer of comments was added. In the following, both layers are referred to as contributions. Importantly, participants could no longer add new lessons learned.

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[6]In the LLCPes prior to InnovProject, the participants voted only on a selection of items.

[7]In the LLCPes prior to InnovProject, the voting was only performed on impact.

The participants' contributions added details to the extant lessons. Similar to ICD1, these contributions also contained additional questions, though the number of questions dropped considerably (see Table E.10 on page 291).

Overall, about 80% of the lessons learned were extended (see Table E.11 on page 291 for details), and the amount of written text approximately doubled (both with regard to number of words and number of comments, see Table E.12 on page 292).

12.2.3 Post-processing Phase

The post-processing phase aimed to integrate lessons learned from all LLCPes in the project (not just InnovCol) into a lessons learned report for the funding organization, thus fulfilling one of the purposes of this LLCP. The elaborated lessons learned from ICD3 served as one input for this phase. Writers used this input to actually create the report.

12.3 Characterizing the Collected Lessons Learned (InnovCol)

This section outlines characteristics of the intermediary lessons learned. InnovCol resulted in 14 drafted lessons learned. The collected lessons learned contained both process (9 lessons learned) and product knowledge (8 lessons learned). Furthermore, some lessons learned were concerned with risks. The uncertainties underlying the risks had not been experienced in the project so far, but might occur during future phases of the project, and had the potential to impede the continuation of the project.

2 of the lessons learned documented positive experiences, 4 documented negative experiences, and another 2 documented mixed experiences (e.g., a positive experience with regard to an activity, combined with the insight that the activity was started too late in the process). 6 lessons could not be categorized, e.g., because the actual experiences in the project were not documented. In other words, these lessons learned only listed recommendations.

It is noticeable that the lessons learned did not follow any discernible structure, and remained in a state of ongoing discussions.

12.4 Evaluation (InnovCol)

The evaluation for InnovCol focused on a survey with the participants who provided insights into the perceived quality of the collected lessons learned.

12.4.1 Demographics

The survey was returned by 10 out of 14 participants (the response rate was 71%). The respondents (one woman, 8 men, one unknown gender) included both individuals with an engineering background and with a management background (e.g., project manager, funding manager). Their age ranged from 25 to 59 (see Table 12.2 on the next page), and their nationality grouped them in North-Western Europe (see Table 12.3).

Table 12.2: Age groups (InnovCol)

Age Group	Frequency
25 to 29	3
30 to 34	1
35 to 39	1
45 to 49	2
55 to 59	1
Unknown	2

Table 12.3: Nationality (InnovCol)

Nationality	Frequency
Belgian	3
British	1
Dutch	4
German	1
Swiss/ Dutch[a]	1

[a]double nationality

12.4.2 Perception of the Collected Lessons Learned

The respondents' assessment of the process output is displayed in Table 12.4. Overall, responses indicated a weak positive perception of the quality of the lessons learned, and were weakly satisfied with the results of the process. The results for the commitment items are a bit lower, with neutral to weak positive median commitments towards lessons learned and recommendations, respectively.

Table 12.4: Quality of LL (participant perspective in InnovProject)

	N	Median	Q1	Q3
Scales				
Content quality of LL	10	5	4.04	5.42
Satisfaction with results	9	4.75	3.75	5.13
Items				
Sufficient context	10	5	4.75	5.5
Commitment towards recommendations	9	5	3.5	5.5
Commitment towards problem descriptions	10	4.5	4	5
Commitment towards LL	10	4	3.75	5

12.4.3 Qualitative Results (LLCP)

The qualitative comments led to a nuanced assessment of the LLCP. On the positive side, the respondents supported the use of the interaction settings in combination with the GSS to start the initial collection of lessons learned.

However, one respondent criticized the selection of lessons learned in ICS2 by pointing out that all invited participants should have the opportunity to participate „to the largest extent" in ICD3. This issue was taken care of by adapting the selection technique for topics (see also ICD3 in Section 12.2.2.3 on page 198).

In addition, two respondents criticized the interaction setting and focus of ICD3 indicating that the results of ICD3 had two shortcomings. First, some lessons learned were considered „vague", indicating a lack of detail. Second, the resulting lessons still contained diverging opinions that one respondent attributed to unresolved discussions between experts and non-experts. Due to the anonymity in these activities (as part of the interaction setting), an author's expertise was not recognizable. This objection is in line with literature on anonymity: Valacich et al. (1992) already suggested that participants may not want their contributions to be anonymous, if they place value on being able to identify and refer to the author of a solution or opinion.

To address these issues, they asked for an activity that obtained alignment between participants, formulated lessons learned more clearly, and added more detail to the lessons learned, e.g., by utilizing a face to face interaction setting to fulfill these tasks.

Overall, these criticisms and suggestions indicate that the quality of the collected lessons learned could be improved through activities focusing on organizing and reducing the collected contributions.

12.5 Discussion and Conclusions (InnovCol)

This chapter presented a detailed analysis of InnovCol based on the intermediary results collected throughout the process, a questionnaire offered to the participants, and an interview with the facilitator delivering insights into the design.

InnovCol was a facilitated, collaborative, designed process that focused on collecting technical lessons learned. In this research, it showed several unique characteristics.

Most importantly, it was the only process that utilized a GSS to allow participants to work asynchronously as well as synchronously, and from various locations. Insights into the preparation activities showed that these interaction settings were intentionally chosen for time management purposes: they Reduced traveling time in a geographically distributed team and allowed for varying schedules of the participants (see also challenge **Env3** on page 62 and challenge **Att2** on page 62).

Furthermore, it is the only (confirmed) case that asked an expert on the project (here: the session owner) to monitor the quality of the contributions.

Next, InnovCol was the only case successfully collecting such a high percentage of positive lessons learned, as well as knowledge about the final product intended to be created in the project.

Last, InnovCol was the only process that did not rely on a simple majority opinion for selecting lessons learned. Instead, after adapting the process at the participants' request, the selection of lessons learned was stratified by theme in order to create an opportunity for *all* participants to contribute in the last group activity.

The quantitative evaluation of the process outcome and the characterization of the collected lessons learned showed that the process successfully collected lessons learned covering all themes identified during the preparation activities. Unlike the other cases observed in this research, the ratio of positive to negative lessons learned was balanced (though a considerable part of the collected lessons could not be categorized due to a lack of documented experiences). InnovCol was also the only case that collected a considerable number of lessons on the product developed in InnovProject. Notwithstanding the assumption that lessons learned containing product knowledge are predominantly useful for projects involving the same product (see also Box 3.3 on page 43) in InnovProject this was actually desirable, as the funding organization requiring the lessons learned focused on products of the same type. However, even though the quantitative evaluation indicated that the quality of the lessons learned was acceptable, the detailed comments and the characterization of the lessons learned showed that the lessons learned lacked structure, some lessons learned lacked specificity, and some lessons learned still contained diverging opinions. Depending on the extent of these deficits, these lessons may be difficult to use, because they are difficult to understand due to a lack detail and structure (see also the general quality criteria in Box 3.3 on page 43), or because a potential user does not know which opinion to follow. Addressing these weaknesses in the post-processing phase would have require rework (e.g., for obtaining additional insights from the participants), which contradicts the task goal of the LLCP.

Overall, InnovCol was successful in collecting a balance of positive and negative lessons learned for projects developing the same type of product. While the overall quality of the lessons learned was perceived as acceptable, the qualitative comments and the characterization of the lessons learned indicated that some lessons learned may be difficult to use.

In the following, this section explores the transferability of the abstracted process to similar lessons learned collection opportunities, starting with the question to what extent the abstracted process can account for characteristics of the collected lessons learned.

Similar to the other cases, InnovCol showed some relationships between key characteristics of the collected lessons learned and aspects of the abstracted process.

On the positive side, the level of detail was successfully influenced by the deficiency monitoring performed by the session owner. The selection of themes was shaped during the preparation of the LLCP. Furthermore, the selection of lessons learned in ICD2 reduced the *quantity* of collected lessons learned. ICD2 may also have had an effect on the topics addressed by the lessons learned, though an expert evaluation would be needed to assess which topics listed together with the themes were actually covered by the lessons learned. In contrast, the main phase of the process did not change which *themes* were addressed in the process due to the stratified selection technique.

On the negative side, the abstracted process lacked some design elements, which may have shaped the resulting lessons learned as well. First, a lack of discernible structure in the lessons learned was associated with a lack of guidance on a format of a lesson learned. In contrast to, e.g., DeepwaterCol, the design did not use a template or guiding questions to guide participants in structuring their contributions. Instead, InnovCol relied on the participants' conceptualizations of lessons learned (the introduction did not define the concept of a lesson learned, and the participants had to use their own understanding of the term). If participants do not know how to structure a lesson learned, or do not communicate their own knowledge on that aspect (such meta-communication on the process was not part of the communication documented in ICD1 and ICD3), a lack of structure in the lesson learned would result.

Second, the some lessons learned remained in a state of discussion, with non-specialists contradicting experts. Participants' attributed this to the design of the process. This notion is supported by the abstracted process as outlined in this chapter: none of the collaborative activities asked the participants to build any consensus on the content of the lessons learned, e.g., by agreeing (or agreeing to disagree) on conclusions. In addition, the anonymity used in the interaction settings made it difficult for readers to judge the validity of a contribution based on a participant's expertise and role in the project. Both the lack of structure and the lack of consensus require further research in order to address these issues while maintaining the unique characteristics of InnovCol with regard to the asynchronous way of working.

Overall, the abstracted process positively influenced the level of detail, reduced the *quantity of the collected lessons learned, left the selection of themes unchanged, and may have influenced the topics covered by the lessons learned. A lack of appropriate design elements may have shaped the lack of structure, and the lack of consensus on the actual lessons learned.*

When transferring the abstracted LLCP to similar collection situations, these outcome characteristics *may* therefore reoccur.

However, there are three reasons why reoccurrence may not be observed. First, reoccurrence does not just depend on the abstracted process, but also on factors associated with the participants and the environment (see Chapter 4 on page 45). For example, questions trying to improve the level of detail will only be successful if participants are actually able to remember these details. Similarly, if the project environment imposes barriers to actually taking up the abstracted process, no lessons learned will be collected.

Second, the participants and the session owner need to actually adhere to the described abstracted process. In practice, this can be difficult to achieve, because the facilitator or moderator cannot monitor all communication channels in this abstracted process due to the interaction settings in combination with the GSS. For example, when working at the same time and co-located, participants have the opportunity to orally discuss the topics in ICD1 and only document part of the discussion. These monitoring restrictions influence the possibility to add (or inhibit) deficiency discovery, and may consequently change outcome characteristics.

The (lack of) restrictiveness imposed by the GSS may mediate the effect of the abstracted process on outcome characteristics.

In contrast to the outcome characteristics discussed so far the high percentage of positive lessons learned and lessons learned with product knowledge could not be attributed to any design elements of process. On the one hand, this could be due to unobserved and undocumented elements of the abstracted process. On the other hand, the participants' positive perception of the project and the focus on the project on novel technology may have contributed to these high percentages of positive lessons learned and lessons with product knowledge, respectively. Thus, it remains an interesting question whether these high percentages could be observed when transferring the abstracted process to other lessons learned collection opportunities with similar positive perceptions of the project, and a focus on novel technology.

Further research is needed to understand to what extent the high percentage of product knowledge and positive lessons learned was affected by the participants' attitudes and the project characteristics.

Last, this example also illustrates an issue resulting from the data collection used in this case study. As it was not feasible to observe the communication of participants outside of the GSS (e.g., in the co-located interaction setting), the description of the abstracted process may be incomplete. Also, if the participants deviated from the instructions provided by the facilitator, such deviations could not be detected just by analyzing intermediary results of the process.

Consequently, the limited availability of data may have resulted in an incomplete description of the LLCP, which may pose a barrier to reproducing outcome characteristics.

Part III

Cross-Case Reflections

Chapter 13

Reflections on Process Outcomes

The previous chapters have presented findings on how lessons learned were collected in all cases, and discussed to what extent the respective LLCPes influenced the collected lessons learned.

This chapter first compares and reflects on the process outcomes, with a focus on variations in the resulting lessons learned. This presentation treats the LLCP as a single variable influencing the process outcomes.

Even though the exact content in lessons learned differed between cases, content characteristics were similar. Table 13.1 on the facing page compares the LLCPes based on several characteristics identified in Chapter 4 on page 45 and Chapter 3 on page 33.

Chapter 4 on page 45 identified four outcome characteristics influenced by challenges relevant for LLCPes. The study found that it can be challenging to simultaneously obtain a high quality (challenge **Out1** on page 61) and quantity of lessons learned (**Out2**), to ensure a high percentage of unique lessons learned (**Out3**), and to achieve a balance of positive and negative lessons learned (**Out4**).

Regarding **Out2** it is noteworthy that the LLCPes collected only a subset of possible lessons learned, intentionally limiting the quantity of potential lessons learned.

Similar to findings on **Out4**, the cases typically produced *negative* lessons learned, though, for IC, the results are tentative due to the high number of uncategorized lessons learned. Thus, FoodOrg is the only organization studied in this thesis claiming to typically collect positive instead of negative lessons learned. In contrast to Baaz et al. (2010), the cases also identified mixed lessons learned that referred to both positive and negative experiences (in both DC and IC). Also, the lessons learned in DC indicated that, in a Department-based approach, the framing of lessons learned as either positive or negative could be a choice for some lessons learned.

Regarding the other two outcome characteristics, **Out1** is addressed in Section 13.2 on page 214. The uniqueness of lessons learned **Out3** was not assessed in this thesis due to restrictions in the case setups.

Table 13.1: Cross-case comparison: characteristics of the collected lessons learned

	Number of positive versus negative LL			Existence of LL with a focus on product or process		LL focus on usage in	Preventing versus reacting to events
Case	Positive	Negative	Other	Process	Product	project vs organization	
Deepwater Col I & II	0	9	0	yes	no data	project	prevention of events dominates
Repository Col	1	13	0	yes	presumably not	no data	prevention of events dominates
Department Col I & II	1	9	2	yes	in case II	both	prevention of events dominates
Refinery Col	1	23	0	yes	no	mainly project	prevention of events dominates
Termination Col	0	18	2	yes	no	project	prevention of events dominates
Innov Col	2	4	8	yes	yes	no data	no data
Theory	Results from Chapter 4 on page 45 found both a dominance of negative and a dominance of positive LL (the latter in FoodOrg, for example).			Newell et al. (2006) found (in projects in the UK) that product knowledge dominated.			Chapter 3 on page 33 found that users only search for lessons learned when they are aware that they have a problem.

13.1 Structured Lessons Learned

Using the characterization of lessons learned in all cases except InnovCol[1], an underlying macro-structure could be extracted. The macro-structure encompasses both to the past or present (as an ongoing situation, particularly in DC), and an envisioned future. It refers to elements in the lessons learned, not the labels used to describe them. It consists of two main components: (a) experiences (typically oriented towards the past or present), referring to perceived events, situations, and outcomes described in the lessons learned, and (b) components oriented towards the future.

A scheme describing the **experiences** is[2]:

„ <contributing factors/attributed causes> led to/ leads to <events /situations>, which had/ has <consequences> and, ultimately, an <impact> on the project"

Figure 13.1 displays an example for such a structure, and shows how structures found in the cases align to it (for RP, only the structure of a selected lessons learned is shown). The circles indicate that certain elements can exist in a lesson learned, but their number is not indicative of how many of these are present in a particular lesson learned. In particular, apart from the events or situation, none of the elements have to be described in a lesson learned.

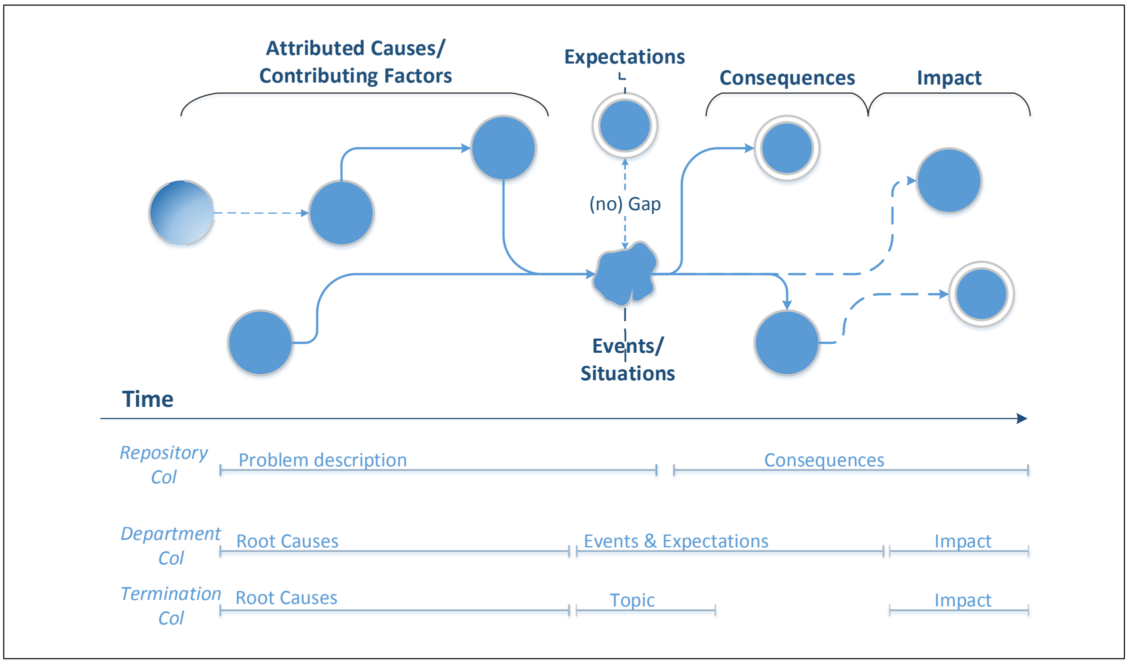

Figure 13.1: Example of the generalized macro-structure of LL without the advisory component, and its alignment with LL found in the cases

For *negative* lessons learned, the perceived contributing factors /attributed causes, events or situations, and consequences describe undesired sequences with perceived

[1]InnovCol was excluded because the resulting lessons learned did not follow any discernible structure and remained in a state of ongoing discussion (see also Section 12.3 on page 201). To test whether an alignment of experiences documented in InnovCol with the meta-structure was feasible, an assessment made by the participants of that case would have been needed.

[2]Hillson (2002) used a similar scheme for describing risks that used keywords similar to those in the lessons learned templates found in the LLCPes.

causal relationships. They could be described in the past, or on a general level. The impact typically refers to past (or ongoing) effects on values (i.e., broad preferences in outcome characteristics, based on (Schermerhorn et al., 2012, p. 38)) prevalent in a project, such as effects on schedule, budget, quality, and safety (found in, e.g., DP and RP). All of these elements can contain evaluative judgments as well. In RC, the impact could also include other values important to the author of a lesson learned such as stress associated with the work. Importantly, the impact can form an explicit tie to the value-system of the organization collecting lessons learned[3].

Elements of this scheme could be systematically missing in the actual descriptions of lessons learned, or were summarized under varying labels (see bottom part of Figure 13.1 on the facing page). For example, RP produced lessons learned that listed causal factors and events under a problem description, while TC skipped a detailed description of the actual events in the lessons learned, and instead used a title. In addition, while the labels used in most cases in MarineOrg focused on events as something happening, the actual content could be limited to situations.

In the cases, the content described in the macro-structure was not limited to the actual. Surprisingly, it contained *imagined* elements to further describe the context of lessons learned (indicated in Figure 13.1 on the preceding page through a circle with an outer ring). In negative lessons learned in DP, DC, RC, the actual events or situations were systematically contrasted with an alternative past (the <expectations>) outlining a *better* reality. This alternative past often seemed imagined, though in DC, participants also contrasted projects with each other. A rare use of imagined alternatives to the past occurred on the level of consequences (identifying potential additional consequences in RP) and impact (outlining how outcomes in the project could have been worse in RC).

Positive lessons learned differed slightly from the negative ones. For the two positive lessons learned in DP, expectations could match actual events/situations. As a consequence, there was no gap between expectations and events. Alternatively, expectations could form an imagined downward-oriented contrast to the actual events/situations, leading to a lesson learned where the actual exceeded expectations. In this context, consequences might also result from such downward-oriented expectations (not shown in Figure 13.1 on the facing page).

Also, the positive lesson learned in RP showed that lessons learned can describe existing practices in an organization if that practice is contested during a project. In this context, the lesson learned reconfirmed expectations, and showed that the practice should be continued even under adverse circumstances (which is an example of a lesson learned in the „keep doing" category).

Components referring to the future include the two types of responses identifiable in the lessons learned structures: recommendations and actions. Recommendations give *advice* on how to deal with undesired causal sequences or on how to reach the expectations. As they compose advice, the ultimate decision if, to what extent, and how a recommendation is followed lies with the user of a lesson learned. Actions move the recommendations towards an implementation. They specify concrete steps that can be taken on an organizational (found in DC) or project (found in TC) level. In DC and RC, actions in LLCPes were pre-decisional, i.e., they still required an official approval. In

[3]Consequently, if one of the presented LLCPes is transferred to another type of organization, the impact dimensions might need to be adapted to the target organization.

contrast, actions in TC were post-decisional. TC also identified an individual responsible for implementing the action.

13.2 Aligning Lessons Learned with Usage Processes

Knowing that lessons learned varied in their characteristics across cases is one point of interest. Perhaps more important is an understanding of how the lessons learned, and particularly the recommendations, align with potential (or actual) usage processes. To understand this relationship, this section reflects on how the collected lessons could align with the possibilities for using lessons learned discussed in Table 3.2 on page 41.

Overall, there are potential matches between the collected lessons learned and the characteristics identified as important for usage. First, the LLCPes typically collected lessons learned outlining how to do things in their recommendations (targeting the *process*). These lessons learned focused on the softer aspects of project work (e.g., communication, team composition, human resources). Only IC and DP II explicitly addressed detailed aspects of the products created in the project, or services offered by the Department.

These findings stand in contrast to findings obtained in a cross-case study in the UK, in which product knowledge was found to dominate (see Newell et al. (2006)). As the same authors suggested that process knowledge has a higher probability of being useful to future projects than product knowledge (see also Section 3.5 on page 43), the focus on process knowledge observed in this thesis might be beneficial for the usage of lessons learned.

Table 3.2 on page 41 aligns the usage of lessons learned with a decision making process, distinguishing between the intelligence and the design phase. In all cases (except IC – the lessons learned were to unstructured to identify any components in the lessons learned) the lessons learned contained problems or causes and events, suggesting that these lessons learned addressed the *intelligence* aspect. Similarly, the lessons learned (except for IC) contained recommendations or actions. Typically, these recommendations or actions focused on what to do about undesirable situations, thus these lessons learned were not limited to the intelligence aspect, but also addressed the *design* aspect[4]. Neither recommendations nor actions had to be tried out in the originating project or department. Instead, they typically contained ideas on how to approach a problem. Thus, *lessons learned document beliefs – but not necessarily knowledge – on what could have worked in the past, or what could be done in the future to address a problem.* As a result, they might not be effective (yet) and require additional design iterations to add details or adaptations to fit them into a new project. Therefore, such lessons learned should be used as initial ideas or potential solutions, but might not be suitable for usage without modification (and might require an evaluation after their usage).

Despite these potential matches between lessons learned and usage scenarios, a closer look indicates that not all identified usage processes are covered in the recommendations or actions. This can lead to systematic gaps between a user's needs or expectations and the actual recommendations suggested in the lessons learned.

First, the lessons learned seemed to hardly contain any recommendations that can be

[4]Please note that this does not indicate that the recommendations were feasible.

used 'out of the box' and that have been shown to work reliably. There are two causes for this: the lack of positive lessons learned, and, for negative lessons learned, the focus on how to do things differently in future projects.

Second, the lessons learned were typically not *suited for reacting* to negative situations once they had occurred (though exceptions existed). Instead, they focused on *preventing* events/situations or even causes, or reducing effects of events through early activities in the project. Thus, a user already experiencing a problem situation in her project might not find the lessons learned useful for addressing the immediate problem (see also Chapter 3 on page 33 and Newell et al. (2006), who studied this issue through interviews). Nevertheless, this does not mean that the lesson learned cannot be used for prevention of further problems once the immediate one has been addressed.

Lessons learned relying on actions could lead to a similar scenario of *being too late*. For example (based on lessons learned found in DC), a project could find that, even if they wanted to follow the recommendations early on in their project, the preparation prescribed in the actions had not been performed.

Furthermore, there could be a lack of temporal alignment between the involvement of the project team (or engineers from a Department) in a project, and the envisioned recommendations. For example, participants did develop lessons learned that required a usage in the early conceptual phases of a project (with an envisioned implementation prior to the involvement of the project team), such as lessons learned for the tendering phase (found in DC) or lessons learned on the development of a project premise document (found in RP). Without possibilities for organizational usage such lessons learned might be useless because of their mistimed envisioned usage (see also RP, where this was considered problematic).

This lack of temporal alignment is part of a larger issue: the participants' *boundaries of influence and expertise* were not always a definitive feature of recommendations or actions – both could break the boundaries of influence and expertise represented by the participants (see also the following reflection on participant selection in Section 14.9 on page 240). Apart from the mentioned lessons learned for the tendering department, engineers developed recommendations for project managers in DC as well. As a consequence, participants in DC had to reason what the tendering department or the project managers could do, and would be willing to do. While the feasibility of such reasoned recommendations could not be assessed, this type of setup might lead to lessons learned that are difficult to use.

13.3 Usefulness and Credibility of Lessons Learned

The alignment between usage processes and recommendations is not the only factor influencing the usefulness of lessons learned.

For recommendations or actions (in negative lessons learned) to be beneficial, for example, they must be functional in actually reducing or preventing the consequences of events or the impact. Even though the case research does not allow a comprehensive assessment of the usability of recommendations, the cases contained evidence that the LLCPes created both functional (e.g., the usage of lessons learned in TC, and the serendipitous use in RP) and impractical recommendations in RP.

The usefulness of lessons learned might not just depend on content-related factors but also on context-related factors. Mechanisms identified in other lines of research may help to identify such factors. Cross and Sproull (2004) suggested[5], for example, that it can be risky to allow others to influence one's thinking via problem understanding or by developing confidence into one's ideas on solutions, because the trajectory of a project is then in another person's hands. As a consequence, a user of knowledge needs to sufficiently trust a source to take these risks.

The previous section posited that lessons learned document beliefs, but not necessarily knowledge, on what could be done to address a potential problem in a future project. This leads to the question why users searching for lessons learned should trust them. In this context, the cross-case workshop identified credibility (defined as „ the quality of being believed or accepted as true, real, or honest" ("Credibility [Simple Def.]", nd)) as a key variable.

Credibility might have been influenced by three factors varying across the cases. First, collecting lessons learned in a group (observed in all cases except RC) ensures that it is not just one person's opinion, but includes several sources with varying perspectives. Involving multiple organizations might have a similar effect. Involving a variety of perspectives might imply that the resulting lessons learned represent a consensus between participants (unless stated otherwise in the lesson learned, an example of which could be found in DepartmentCol). In turn, consensus is a heuristic to judge correctness of information (Eagly and Chaiken, 1993; Chaiken and Maheswaran, 1994).

Second, after the LLCP, lessons learned were evaluated by (identifiable) verifiers with regard to their correctness (found in DP, DC, RC).

Last, the authority and expertise of the contributors or authors (as the sources of information) is an important indicator for judging the credibility of information (see, e.g., Chaiken and Maheswaran (1994)). RC explicitly stated the author of a lesson learned, which was enabled through the lessons learned application. Thus, his or her expertise could be used to judge the credibility of a lesson learned. Interestingly, original contributors were obscured in the lessons learned collected in a collaborative approach. Participants of LLCPes were not associated with lessons learned to which they made contributions (facilitated through an anonymous[6] setting such as in IC), or these associations were stated only as a verifier (DC, identified as a contact person during DP) or implementer (TC) and not as an author. RP identified contributors to a lesson learned, but even in this case components of a lesson learned such as recommendations could not be traced to the originating contributor. As a consequence, their expertise could not be used to judge the credibility of a lesson learned. All in all, for collaborative LLCPes, organizations and projects could often be identified, but individual contributions were obscured. This lack of traceability of contributions was a consequence of the chosen interaction setting. Oral discussions between participants (as used in DC, DP, and TC) impede any effort to keep a record of who made what contributions. In contrast, obscuring authorship was chosen intentionally for IC and RP (the reason for which are outlined in Section 14.10 on page 243).

[5]Please note that this research has been performed for networking approaches to knowledge management, not for codification approaches. Transferability of findings to the context of lessons learned is therefore a matter for future research.

[6]Please note that this was a design choice in InnovCol. Valacich et al. (1992) pointed out that it is possible (e.g., with the support of an appropriate GSS) to create anonymity during a group process and allow other after a group process to identify the authors of a contribution.

Eagly and Chaiken (1993) suggested that these heuristics are learned – their applicability might therefore be mediated by a user's past experiences as well as professional judgments and the organization's culture. Also, these considerations on the credibility of lessons learned are theoretical in nature, as the perceived credibility was not systematically assessed in the case research.

13.4 Lessons Learned as Risks for Future Projects

During the work on RefineryCol, the idea to use lessons learned as risks in future projects was discussed. Also, (Collier et al., 1996) considered lessons learned to be risks for future projects. The idea underlying this proposition is simple: lessons learned show that specific events or situations (that are not 'business as usual') happened in the past. Thus, there might be chance that they happen in future projects as well. Nevertheless, lessons learned and risks are so far treated separately in project management (see, e.g., Project Management Institute (PMI) (2004)).

To further understand the relationship between lessons learned and risks, this section analyzes similarities and differences between them. Both risks and lessons learned can be positive and negative. Negative risks represent losses or hazards, for example, while positive risks are opportunities, that is, uncertainties with a positive effect on a project (Hillson, 2002). The following sections focus on negative lessons learned and threats, as there was not sufficient sample of positive lessons learned available for comparison.

If lessons learned are used as risks, it must be possible to transform them into risks. A match in meta-structure would allow an integration of lessons learned into a risk register (possibly with clear guidelines on what needs to be changed). Hillson and Simon (2007) identified a metalanguage that describes risks as consisting of causes, risks (defined as uncertain events or sets of circumstances), and effects on the objectives of the project.

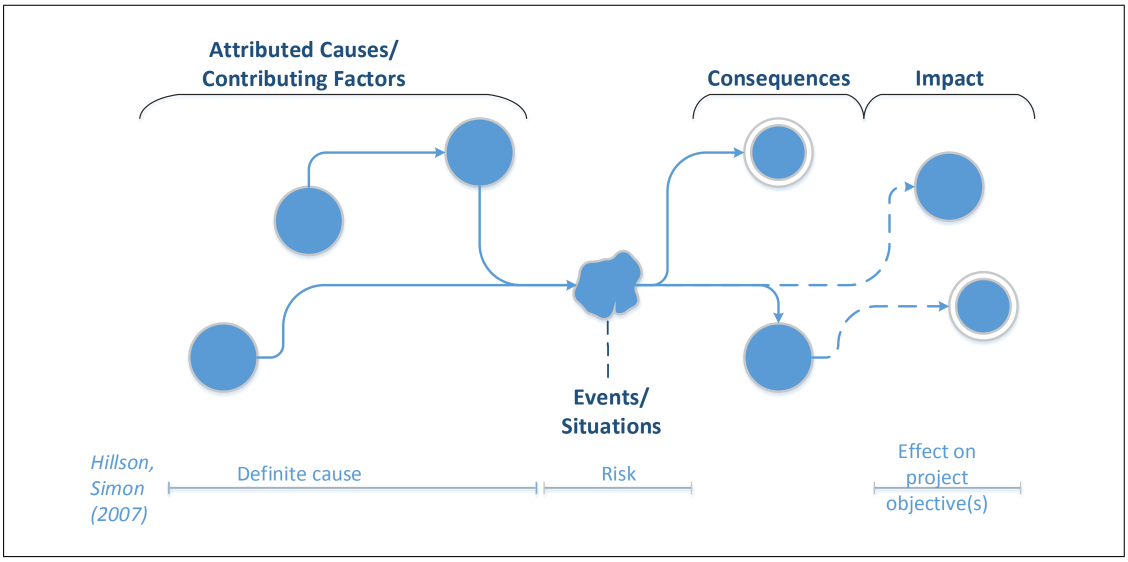

Figure 13.2: Mapping risks to lessons learned

Figure 13.2 maps these elements to the meta-structure developed for lessons learned. It shows that the basic elements seem to be similar for both lessons learned and risks.

One difference between lessons learned and risks is that lessons learned can contain the desired events or situations (in the form of expectations and a gap) as a counterpoint to the actual events or situations. Also, Ward (2003) argued that risks can be any source of uncertainty, not just events or circumstances (as implied by Hillson and Simon (2007)). Another difference is their level of reality. For lessons learned, events and situations have been experienced, whereas for risks the events or circumstances are hypothetical. Using lessons learned as risks therefore assumes that events and situations of the past are uncertainties in future projects. Last, there might be difference in causes. For the lessons learned observed in this thesis, causes are typically constructed by participants. As a consequence, the constructed explanations might be false. In contrast, causes in risk management are existing conditions that can result in an uncertain condition (the risk) (Hillson and Simon, 2007).

Recommendations in lessons learned suggest what to do in future projects. Their equivalent in risk management are response strategies. Types of recommendations for negative lessons learned, and possible response strategies for risks (as outlined in Hillson and Simon (2007)) show both similarities and differences. On the one hand, threats can be avoided (i.e., the threat has no impact on the project objectives) or its effect can be reduced. Both response strategies can involve reducing the impact of the causes or events/situations on a project. Recommendations follow a similar logic in that they aim to reduce the effect of causes or event/situations in order to achieve expectations. On the other hand, risks can be accepted, that is, the project team decides to reserve time, money, or resources in order to live with the risk. Such acceptance strategies have not been observed for lessons learned. In addition, threats can be transferred to other stakeholders in a project. While lessons learned contained recommendations for other stakeholders, prominent examples mixed this with a usage on an organizational level.

Both the mapping of risks to lessons learned in Figure 13.2 on the preceding page and the partial overlap in types of recommendations with risk strategies indicate that there is a match between negative lessons learned and threats indicating that lessons learned can be used to inform risk management in future projects. Thus, negative lessons learned can deliver suggestions for response strategies, but future projects should make the final decisions. Also, they might have to adapt recommendations to their particular context. Whether a similar mapping as possible for positive lessons learned and opportunities remains a matter for future research, as this thesis did not encounter enough positive lessons learned to develop a meta-structure.

Risks might be prioritized before potential responses are planned Hillson and Simon (2007). If lessons learned are not be filtered out due to a low severity, they would need to have at least a similar severity for a future project. The severity of a risk can be assessed by combining the probability of their occurrence and their expected impact on a project. RP illustrated that such an assessment is useful to understand the impact of lessons learned on a project. However, DP indicated that these results might not be transferable to future projects. Thus, to what extent the potential impact changes when using lessons learned as risks remains a matter for future research.

To conclude, there are tentative indications that lessons learned might help to identify possible risks and recommend responses, but they might not be useful for setting priorities for future projects or enforcing choices with regard to responses. Thus, the integration of lessons learned into risks might offer an opportunity to improve both the usage of lessons learned, and the quality of risk management.

Similarities between lessons learned and risks do not just occur of the structural level, but also with regard to characteristics of the set of lessons learned. Risks are typically understood as threats (Hillson, 2002; Hubbard, 2009; Ward, 2003). Similarly, the lessons learned studied in this thesis typically focus on events or situations that did not meet expectations. Thus, both lessons learned and risks center on an actual or potential failure. Interestingly, for lessons learned this leads to upward-oriented counterfactual thinking (things could have been better), whereas for risks this requires a downward orientation (uncertainties might lead to unwelcome outcomes, see Ward (2003)).

Further research is needed to investigate whether other similarities exist, in particular, whether the source of uncertainty in actual risks also focuses on softer topics (instead of technical ones). Future research should study the usage of lessons learned as risks, and investigate (a) whether integration results in a better (or worse) understanding of the root uncertainties for risks, and (b) how the quality of response strategies is dependent upon the characteristics of the recommendations.

Also, similarities with regard to a focus on actual or potential failure (negative lessons learned and threats) might indicate further possibilities to understand the causes for this focus on negativity in engineering contexts, and to develop processes that allow the identification of positive lessons learned or opportunities.

13.5 Summary

Even though the LLCPes varied in their approach to collect lessons learned, the outcomes showed some surprising similarities and differences. The results show that two LLCPes stand out: IC, because of the lack of structured lessons learned and state of ongoing discussions in the lessons learned, and TC, because all but one lesson learned had been used within about one year after their collection.

A major finding of this chapter is that, despite these different processes, there seems to be a shared macro-structure underlying the (structured) lessons learned that documents actual and imagined experiences from the past (optionally generalized), and recommendations and actions aiming to prevent undesired events.

The results showed further that, despite these different LLCPes, the sets of collected lessons learned were similar in three aspects of their potential usage. First, they covered the intelligence aspect of a problem solving process. Second, they predominantly created lessons learned focused on process rather than product, on acting prior to events rather than reacting to them, and on why expectations (as outlined in the macro-structure) were not achieved rather than on successes. As a consequence, the observed LLCPes showed major gaps in covering the potential range of lessons learned (no positive, no reactive, and few product lessons learned). These gaps have consequences for how the collected lessons learned can actually be used. Some usage processes such as a reactive usage can rarely be addressed by the recommendations and actions covered in the lessons learned. Also, a further analysis of the recommendations showed that there might be additional gaps of influence/power and expertise between users and participants. Further research is needed to find out whether this translates to additional barriers for the usage of lessons learned. Last, comparing the macro-structure and extant structures used in risk management suggested that lessons learned might be helpful in identifying possible risks for future projects, and that they could suggest responses for these risks (though not all possible responses are covered in lessons learned).

The evaluations of recommendations (and actions) indicated that the set of recommendations could contain recommendations that were considered impractical in an evaluation. In this line, further research is needed aiming to improve the practicability of recommendations.

Last, a closer inspection of the experiences underlying a recommendation or action indicated that they did not have to be tried out in the past, suggesting a potential lack of validity. In the absence of strong evidence that the recommendations or actions could achieve the desired effect, the credibility of the lessons learned was suggested as an important heuristic that could influence the usage of a lesson learned. This chapter identified four factors potentially influencing credibility – being collected by a group, consensus between participants, additional verification, and the authority or expertise of contributors – that could be documented together with a lesson learned.

Chapter 14

Reflections on the LLCPes

The previous chapter analyzed the collected lessons learned, treating LLCPes as a single and complex variable without considering variations in the instruments used in these LLCPes. This chapter draws on findings from all cases in order to obtain a more nuanced understanding of how instruments and individuals in supporting roles shape the outcomes of a LLCP (**RQ3**). To this end, it explores how salient instruments identified in the LLCPes influenced the lessons learned, as well as intermediary outcomes.

Research Approach. To identify salient variations and commonalities between cases, a workshop with three researchers involved in this research was conducted. To distinguish this workshop from workshops occurring in the LLCPes, this chapter refers to it as a cross-case workshop. Using comparing and contrasting across cases, the researchers created an initial case-ordered meta-display on salient variables (see also Miles and Huberman (1994, p. 178)). The variables included instruments and salient effects of instruments typically describing (intermediary) outcomes of a LLCP, such as the selected participants or whether the resulting lesson learned had a uniform structure. After the cross-case workshop, this meta-display was further refined by substructuring the variables (Miles and Huberman, 1994, p. 254), and identifying instruments that created the salient effects (e.g., moving from selected participants to selection criteria for participants). In addition, a comparison and contrast of the actual outcomes (in terms of lessons learned) was added, to develop further explanations on how the instruments shaped the resulting lessons learned.

The cross case workshop identified two key structures (outlined in Section 14.2 on the next page) in the cases: structures for the lessons learned (see Section 14.4.3 on page 234 for details), and structures of the LLCPes. Particularly the latter influences another variable, the means by which standardization was achieved in the cases (see Section 14.3 on page 225). The structure of the LLCPes was further partitioned into (1) moving towards topics for lessons learned (see Section 14.4.1 on page 225), and (2) phases in the LLCPes for creating a single lessons learned (moving from topics to actual lessons learned, see Section 14.4.2 on page 232). Another variable pertained to how deficiencies were discovered throughout and after the LLCPes (Section 14.5 on page 236).

Two variables– tool support (Section 14.7 on page 239) and basic interaction setting (Section 14.6 on page 237) – were relevant for shaping situations in which lessons learned were collected. Another two variables – the facilitation/moderation of LLCPes (Section 14.8 on page 239), and the participants (Section 14.9 on page 240) – focused on the people involved in the LLCPes. Last, the cross case workshop identified factors influencing whether participants would consider it safe to contribute (see Section 14.10 on page 243).

In addition, another variable – project versus department-based approach (presented in Section 14.1) – could be identified as an influence on several other variables (including the key structures, and the participants)

14.1 Project versus Department-based Approach

In order to improve the performance of future, parallel, or the same project, LLCPes were either focused on collecting lessons learned from a single project (the project-based approach, as found in RP, DP, IC, TC, and RC), or from a Department in a matrix organization (department- or discipline-based approach, as observed in RC and DC). These two approaches differed with regard to the reference point for the experiences on which lessons learned were based. The project-based approaches referred to a single past project (though participants could include references to other projects, as observed in RP), and, with the exception of RC, included multiple perspective on that project. In contrast, the department-based approach explicitly considered multiple projects (for a single theme), and could also compare and contrast these projects (removing the tendency to focus on a single project, see **Part7**). Thus, these two approaches created different frames of reference for the participants to consider during the LLCP.

14.2 Overview of Key Structures

For the LLCP, two types of structures were relevant for shaping the content of the lessons learned: the lesson learned structure used in the LLCP, and the structure of the LLCP itself.

Both structures could vary from low or none-existent to more structure. In general, the lessons learned structure used in the LLCP was enabled through templates or semi-structured questions used in the LLCPes. The structure of the LLCP refers to the more or less structured sequence of activities used to collect lessons learned. Figure 14.1 on the next page shows that the observed lessons learned structure varied from no lesson learned structure (observed in IC) to semi-structured (the structure of a lesson learned was adapted to the content, so that variations in structure could be identified, as in RP) to structured (the content was somehow fitted into the structure), optionally resulting in adaptations of the content (observed in DP) or misalignments between content and lessons learned structure (observed in RC). Similarly, the structure of the LLCPes in the semi-structured range from processes in which participants were free to fit the LLCP to their working environment, but the sequence of activities was fixed (IC) to LLCPes with predefined sequences of steps that could be adapted based on the situation and needs of the group.

Relationship between both structures. A lessons learned structure does not determine a LLCP structure. For example, the same structure for lessons learned was utilized in both RC and DC – two rather different abstract LLCPes. Similarly, changing the lesson learned structure between DP and DC had only a minor impact on the abstract

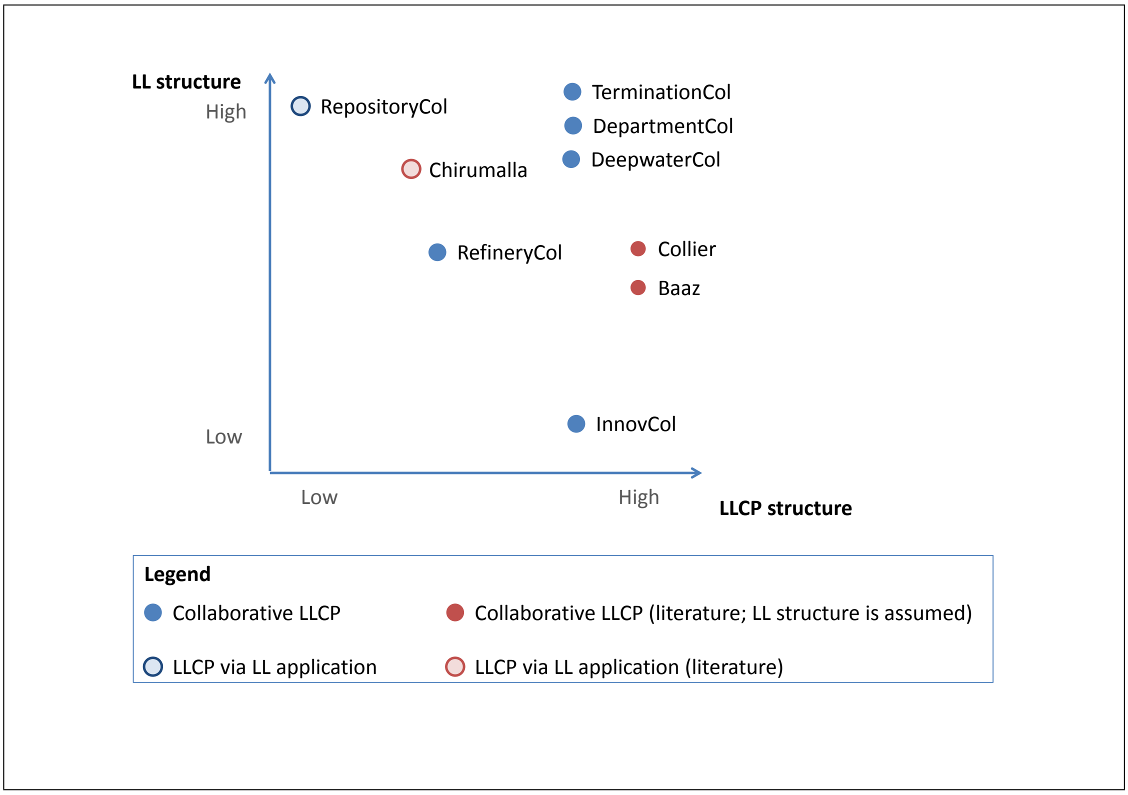

Figure 14.1: LL structures and LLCP structures for the cases, and selected approaches from literature

LLCP in that the question for identifying the key differences between events and expectations were no longer used. Thus, the structures for lessons learned and LLCPes were not entirely independent, but did not determine each other either.

Adaptability. As indicated in the above explanation, the lessons learned structures and the LLCP structures varied with regard to how adaptable they were to the content and the situation in a LLCP, respectively.

Transferability. A comparison between cases indicated that both structures can be transferred between LLCPes. The lessons learned structure was the same for RC on the one hand, and DC on the other hand – while combined with different abstracted LLCPes.

The transfer of abstracted LLCPes was observed between DeepwaterCol I and II as well as DepartmentCol I and II – both pairs of LLCPes created lessons learned with similar characteristics (similar structures, a dominance of negative lessons learned, a focus on preventing events, and a focus on process knowledge) but, of course, different content.

Also, there was a partial transfer from DeepwaterCol to DepartmentCol. While the abstracted LLCP was transferred, the actual approach and theme as well as the participant selection were changed. Lessons learned created in DP and DC showed pronounced variations in their focus: the lessons learned in DC were based on experiences of engineers from several projects, and included actions for the department or organization, while lessons learned in DP were based on multiple perspectives on a single project, and focused on recommendations for future projects. These differences can be explained with choosing a project versus a department-based approach, and the subsequent consequence for participant selection.

This section has identified two structures as key influences on the resulting lessons learned. Section 14.4.3 on page 234 further compares how lessons learned were structured across cases, while Section 14.4 analyzes the structure of LLCPes in more depth.

14.3 Standardization

The potential to achieve standardization of resulting lessons learned, in particular with regard to a uniform structure, was handled differently across cases. First, standardized lessons learned co-varied with an inflexible lessons learned structure.

Both IC and RP used (more or less) flexible lessons learned structures, and did not aim for standardization of lesson learned.

In contrast, DP, DC, RC, TC, with inflexible lessons learned structures, aimed for standardized outputs. These cases utilized three basic approaches to achieve a standardized output. First, lessons learned could be standardized through a lesson learned structure *after the LLCP* in the lesson learned repository (found in DC, DP and RC). Second, the lessons learned structure used *during the LLCP* could contribute to a standardization. In DP and DC, this lessons learned structure was enacted through the use of semi-structured guiding questions that (partially) matched the one used in the repository. Similarly, TC used a spreadsheet and guiding questions to create standardized output (but did not use a repository for standardization). It should be noted, though, that RP also used semi-structured guiding questions. Thus, guiding questions are not sufficient to ensure standardizations. Last, *verifiers* contributed to the standardization after the LLCP (found in DP, DC, RC).

14.4 On the Structures of LLCPes

The structure encountered during a LLCP included structures for shaping what a lesson learned should be about (moving from project or department to topic), and structures for actually collecting lessons learned (moving from topic to lessons learned). Both are analyzed in more detail in the following to sections.

14.4.1 From Projects/Departments to Topics

All LLCPes moved from the broad goal of collecting lessons learned for a project or department to collecting one or more lessons learned for a particular theme or topic.

RC and collaborative LLCPes differed considerably in how the topics of the lessons learned were obtained. Collaborative LLCPes carefully managed and selected the topics leading to lessons learned. In DP and DC, the quantity of collected lessons learned was limited through careful time management (thus dealing with limits in the available time outlined in **Att2**). None of the collaborative LLCPes attempted to systematically collect all lessons learned from a project or Department (influencing the quantity of lessons learned, see also challenge **Out2** on page 61). In contrast, RC did not provide any guidance in this matter beyond a conceptualization of lessons learned.

Of interest for **RQ3** is how the selection of themes and topics for lessons learned was organized in the cases. This section focuses on the flow of activities that identify, rate, or select such themes or topics. As RC did not guide participants on how to identify and select topics, the case is excluded from further analysis. To understand how topics were shaped in LLCPes, a sequence of activities for each case was constructed (using activities as arrows, and potential sets of lessons learned as nodes), including sets of activities that subdivided or actually narrowed or broadened the set of potential lessons learned. Whether activities narrowed or broadened the set of potential lessons learned could often be observed in the intermediary results of this and parallel LLCPes (e.g., how many topics were not covered in the lessons learned? Were there lessons learned covered in parallel LLCPes that were not outlined in the observed case). As a consequence, activities for elaborating and clarifying, topics were not considered, for example. Details on these activities are not outlined here, but can be found in the case chapters.

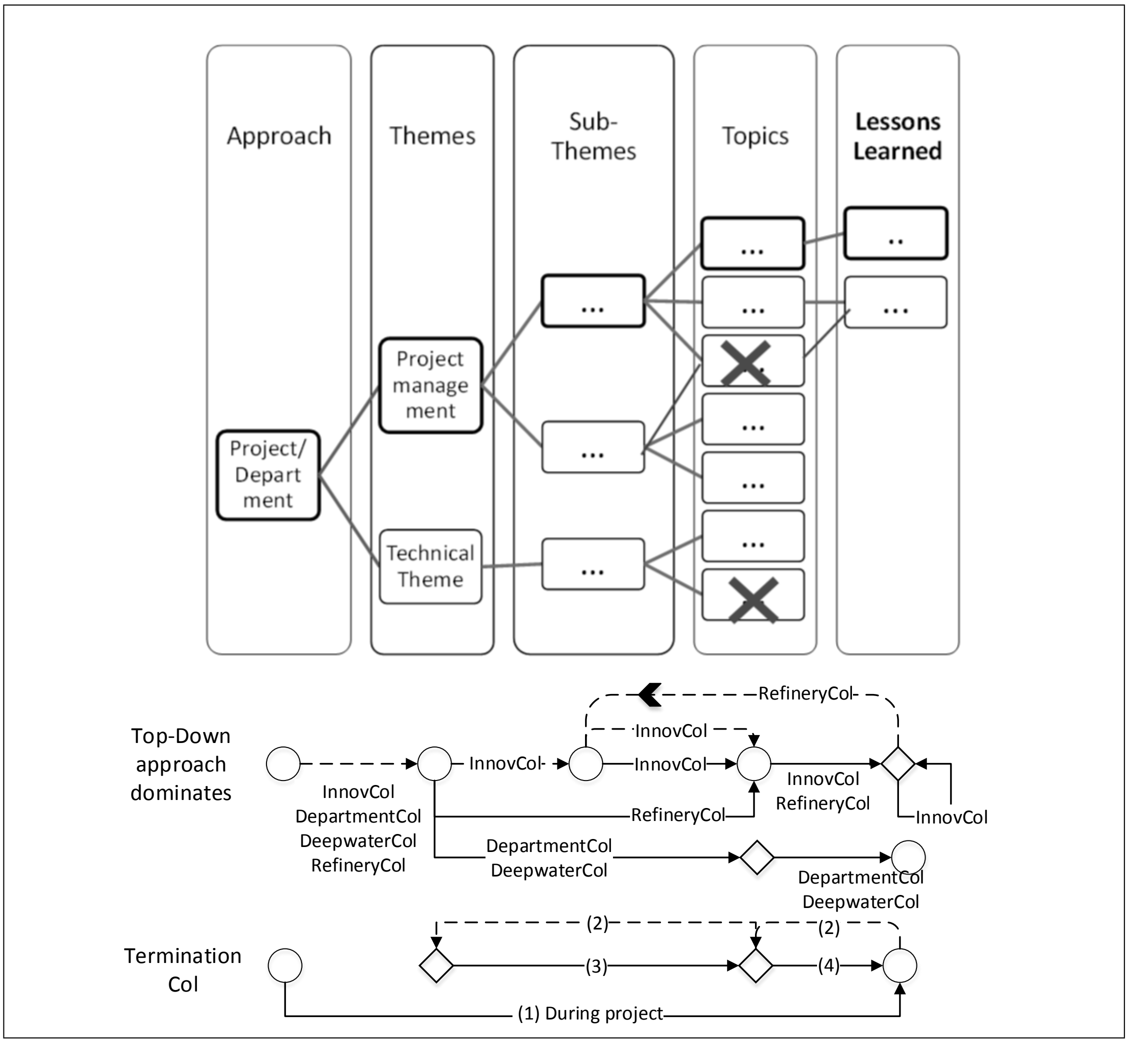

Figure 14.2: Levels of abstraction in topic determination and their alignment with LL found in the cases

Structure and Process. Figure 14.2 displays the salient levels of abstraction used in the LLCPes to identify and select topics for lessons learned (top part of 14.2). Across all cases, there were at least three layers of abstraction (in addition to the lessons learned) that needed to be taken into consideration.

On the most general level, the organization followed a project-based or a department-based approach for a LLCP (see also Section 14.1 on page 223). The decision was usually made in the environment of the LLCP, and seemed to be tied to the decision on whether lessons learned should be collected.

On the most specific level were topics. Topics are short titles or labels that participants associated with one or, as the cases showed, several potential lessons learned. In turn, the cases demonstrated that one lesson learned could be associated with several topics. In between were one or more levels with themes, which are overarching subjects encompassing several topics. High-level themes were found in all displayed LLCPes. For example, RP included project management and technical or operational issues, while DP included the supply chain and specific technical themes. A distinction between themes and sub-themes was found in IC (a technical theme was split into parts of the created product) and RP.

The lower part of 14.2 shows how the LLCPes moved through these levels of abstractions. In 14.2, dashed arrows indicate a breakdown or clustering step performed by individuals in supporting roles, while solid arrows indicate steps taken by the participants. Diamonds indicate that participants rate items on a particular level of abstraction (with the rating optionally being used for selection in later steps), using techniques supporting a group in obtaining a shared rating. With the exception of RP, these group ratings were used as a selection criterion on a given level of abstraction.

All cases with the exception of TC (and RC) initially followed a top-down approach by successively breaking down the goal of collecting lessons learned from a project or department. This top-down approach moved from *identifying* and *selecting* one or more themes in the preparation phase (without participant involvement) to identifying (and to a limited extend clarifying) topics, and then selecting a sub-set of topics for creating a lesson learned. IC included an intermediary level by breaking down the theme into sub-themes (also performed in the preparation phase without the participants), and was also the only approach to include a selection on the level of lessons learned.

RP used a mixed approach: after the top-down phase, the lessons learned from the interviews were clustered into sub-themes in the intermediary phase of the LLCP. RP was the only LLCP in which both sub-themes and ratings of lessons learned were used to organize and describe the lessons learned without further reducing the scope for subsequent activities.

In contrast to these top-down approaches, TC followed a more intricate approach. In the preparation phase, a pre-existing set of topics (created by project members) was clustered into themes. In the main phase, the participants selected a subset of themes (with associated topics), and then decided on discussing a sub-set of topics for each selected theme.

Participants were typically responsible for identifying and selecting topics during the main phase of the LLCP. During rating activities (diamonds in 14.2), the main criterion for selecting topics was their *importance* or *impact on the project* (see, e.g., DP and RP). In DP, DC, and TC, the subsequent selection was, in essence, based on the opinion of the majority of participants (themes or topics with a higher rating were preferred). IC indicated that is approach might not be useful: participants might find that all topics or themes within their area of expertise are dropped, and that their most useful lessons learned would not be collected. To alleviate this problem, the selection of topics was *stratified* by theme in IC.

In addition to this structured approach to select topics for collecting lessons learned, participants in InnovCol and participants or the interviewer in RefineryCol also made a choice on which topics to address (on the step from topic to lesson learned).

Interestingly, one approach suggested by Baaz et al. (2010) follows a different pattern: first, participants identify potential topics, and then clustered these into themes. Lessons learned are then developed for these themes.

Effects on outcomes. The apparent effect of theme and topic selection was to narrow the *scope* of a LLCP down from collecting lessons learned for a project or department to collecting lessons learned on specific themes or topics. In effect, this reduced the quantity of potential lessons learned (challenge **Out2** on page 61). Specific techniques in combination with the group composition (a consequence of participant selection, Section 14.9 on page 240) influenced the actual topics that were considered. In particular, the change in selection techniques (moving from a majority-based selection to a selection stratified by sub-theme) found in IC ensured that all sub-themes were still covered after the selection.

Theme and topic selection might also have shifted the focus of lessons learned towards process rather than the product in cases where the theme was directed towards managing of and working within a project (RP, DP, TC). The influence on process versus product oriented lessons learned might have been mitigated by how the theme and its role was communicated to the participants (in the introduction phases of the cases, but maybe also during the preparation phase).

Themes were used to organize several LLCPes for a project (in DP, RP, IC) or department (DP), or to organize sub-groups working on them in parallel (in TC, and in IC with sub-themes). This helped to organize the process of collecting lessons learned from larger organizational units such as large projects (identified as a challenge, see challenge **Env4** on page 62).

Also, the focus on a single theme might have supported some participants in dealing with the limited time they can spare to collect lessons learned (challenge **Env3** on page 62), because they didn't have to spend time on themes to which they could not contribute.

Lessons learned not fitting into the theme(s) of a LLCP were not or only rarely discussed (observed in TC, DP, DC, RP), and less important topics were only analyzed if there was sufficient time during the LLCP (observed in DP and DC). As a consequence, the time needed to discuss selected topics or themes could be reduced (see particularly the time management in DP and DC), thus addressing limitations in the time available for LLCPes (challenge **Att2** on page 62).

Another (potential) effect on the outcomes pertains to the strong focus on negative lessons learned. It is noteworthy that, in DC and partially in DP, participants were able to categorize topics as positive or negative (or, in DC, also as mixed). Similarly, Baaz et al. (2010) expects participants to be able to categorize potential topics as positive or negative. This shows that the focus on negative lessons learned (**Out4**) is created prior to the actual discussion of lessons learned, and can, in DC, already be observed when participants *identify* topics. Thus, it seems to be an individual's choice (not a group choice) to focus on negative or positive topics. Baaz et al. (2010) showed that it is possible to achieve a balance in positive and negative lessons learned. The key difference between their approach and the cases presented in this thesis is whether or not participants could choose to only contribute negative lessons learned.

Table 14.1: Cross-case comparison: How, when, and by whom was the content created or modified?

Case	Phases[1]	Creating potential content for LL; filtering, organizing, summarizing contributions	Filtering, organizing, summarizing contributions	Adding additional data for retrieval and usage	*Dedicated* activities for improving drafted lessons learned
DeepwaterCol I &II	**Main phase**	participants (partially organized contributions)	facilitator	-	-
	Post-processing	-	facilitator	-	-
	Verification	-	-	*contact person/ participant or knowledge manager adding tags, action, assessing impact*	*contact person/ participant*
RepositoryCol	no data (presumably one)	participant	participant	participant suggesting actions, adding tags, assessing impact	-
	Verification	-	-	*verifier*	*verifier*
DepartmentCol I & II	**Main phase**	participants: main contributions, partially organized **facilitator**: suggesting ideas, providing relevant information	facilitator	participants suggesting actions	-
	Post-processing	-	facilitator	facilitator (assumptions: no data available)	-
	Verification	-	-	*contact person adding tags, and maybe importance*	*contact person*
RefineryCol	Interviewing phase	participants: main contributions **facilitator**: suggesting ideas and causes	-	-	-

Continued on next page

Table 14.1 – continued from previous page

Case	Phases	Creating potential content for LL; filtering, organizing, summarizing contributions	Filtering, organizing, summarizing contributions	Adding additional data for retrieval and usage	*Dedicated* activities for improving drafted lessons learned
	Intermediary phase	-	supporting team: summarizing and merging initial lessons learned	-	-
	Workshop phase	-	-	participants assessing and tagging LL	participants
	Post-processing	-	supporting team: integrating improvements	-	participants: suggesting modifications
TerminationC	**Main phase**	participants	moderator (assumption)	participants creating and assigning actions	participants (assumption: for later rounds of World Café)
InnovCol	**Brainstorm technical LL**	participants (in writing)	-	-	-
	Elaborate on selected LL	-	-	-	participants

In DC, for example, participants were asked to contribute a minimum number of positive lessons learned, but this was not enforced. In contrast, Baaz et al. (2010) used a visualization technique to foster the identification of positive topics, and to allow for easy monitoring.

14.4.2 Phases in LLCPes for Creating a Single Lessons Learned

Table 14.1 on page 230 displays in which phase the lessons learned were modified in which way and by which role. The number of phases in which the content for the lessons learned was modified varied considerably across cases: from one known phase in TerminationCol to four phases in RefineryCol.

Types of functions. The cross-case analysis found four major types of functions influencing how the content of lessons learned was created and modified, ultimately shaping the resulting lessons learned. The first function centered on creating more or less relevant contributions for the lessons learned. The second one focused on filtering out some of these contributions (e.g., personal statements), and summarizing and organizing the contributions into lessons learned. The third one focused on creating additional information for supporting the transitioning towards the usage of a lesson learned. The last one included dedicated activities for improving extant lessons learned.

A quick glance at Table 14.1 on page 230 shows that there were both similarities and differences in how these four functions were spread out across the phases (and therefore across activities) and people (or roles). The spread across phases indicates that the four functions tended to be performed in the order in which they are listed above. It also shows that the last two functions could be done by the participants, or individuals involved in the verification process, and therefore in a different lessons learned process. The spread across roles indicates that not just the participants or knowledgeable experts (verifiers) were modifying the content, but also facilitators or individuals in supporting roles.

Creating contributions. Participants contributed potential content for the lessons learned in the early phases (depending on the case this was the main phase, the interviewing phase, or the brainstorming). Typically, the contributions were created orally, and through collaboration between participants. Exceptions to the collaborative aspect were RefineryCol and RepositoryCol. The former used interviews for separating participants, the latter did not rely on collaborative activities. A more detailed analysis of how contributions were created is presented in Section 14.4.3 on page 234.

Participants were not the only source of contributions. Surprisingly, in two cases, the facilitator contributed to the lessons learned as well (highlighted in bold in Table 14.1 on page 230).

The **filtering, summarizing, and organizing of contributions** was more complex, and could involve several phases. A pre-ordering of contributions was achieved through (a) semi-structured questioning matching the intended lessons learned structure (in DP, DC), and (b) documenting contributions in matching spreadsheets (in DP, DC, TC) or templates (RC). These approaches were only used in LLCPes employing a strong lessons learned structure that could be followed throughout the process.

In addition, individuals in supporting roles were responsible for further organizing, filtering, and summarizing the contributions (in DepartmentCol I & II, DeepwaterCol I & II, and RefineryCol). In this approach, participants could not provide immediate feedback on the summarized lessons learned, as they had no access to the summaries when they were created. In contrast, in TerminationCol, the summarizing, filtering, and organizing were delegated to a moderator. Due to the paper-based spreadsheets used in the LLCP, participants might have been able to observe and correct the activities of the moderator. In addition to these approaches, the post-processing phase in DeepwaterCol I & II, DepartmentCol I & II, RefineryCol, and the intermediary phase in RefineryCol, provided individuals in supporting roles with opportunities to further refine, extend, and correct the summaries.

In RP, the lack of a strong questioning structure for organizing contributions in combination with the intermediary phase for summarizing and organizing the content gathered in the interviews, resulting in more variation in the structures for lessons learned than in the other LLCPes except IC. IC, without any discernible structure for lessons learned, also had no discernible activities for summarizing or organizing the contributions. These variations in how the contributions were organized and summarized explain how stronger and weaker lessons learned structures (described in Section 14.2 on page 223) are achieved.

Overall, in facilitated LLCPes except IC, the task of collecting a lesson learned was typically separated into *orally* creating contributions on the one hand, and organizing and summarizing these contributions on the other hand. Filtering, organizing, and summarizing contributions in collaborative or interviewing activities was predominantly performed by individuals supporting the participants (including a moderator). These individuals were also responsible for creating the *written* lessons learned. Participants could be prompted to pre-order contributions (thus supporting this task), but, except for TerminationCol, could not give immediate feedback on the summaries.

This approach of moving from oral contributions to written lessons learned had two consequences. On the positive side, it was used to create a division of labor. It is much faster to create oral content than to write down contributions. By allowing facilitators to organize and write up contributions in a separate phase, the first function, creating contributions, could be performed more efficiently, potentially addressing issues with limited available time for a LLCP (challenge **Att2** on page 62). This observation applies to all collaborative cases with this approach except TC.

On the downside, even though the summarizing and organizing was supported by audio recordings, the facilitator could have a major (unintended) impact on the collected lessons learned, e.g., because he or she did not understand the importance of a contribution and therefore left it out, or because (s)he misinterpreted the lessons learned.

Supporting (transitions to) other lessons learned processes. An additional preparation of the LL for their usage or retrieval could be identified for every LLCP except InnovCol. It was distinctive in three aspects. First, it could be performed in the LLCP itself, in a process that usually follows on the LLCP (the verification process), or in both processes. It was typically performed by the participants or a verifier, though the facilitator might also have been involved. Second, it could result in three major outcomes: tags and categorizations for lessons learned, a quantitative assessment of the impact of the lessons learned, or actions to be taken in the organization (DeepwaterCol I & II, DepartmentCol I & II, RepositoryCol) or the same project (TerminationCol).

Improving the quality of contributions was a continuous effort throughout the LLCP. Nevertheless, each case also had dedicated activities for this purpose. Similar to the preparation of lessons learned for their usage, these activities could be found towards the end of the LLCP or in the verification process (see also Section 14.5 on page 236).

14.4.3 Structuring Lessons Learned

Section 13.1 on page 212 showed that lessons learned seemed to be based on a shared meta-structure. Nevertheless, the cases varied with regard to how lessons learned were presented to a reader – both within cases (for adaptive lessons learned structures) and between cases (see also Section 14.2 on page 223).

As lessons learned without any structure might to be difficult to understand (see Chapter 3 on page 33), and have been found to remain in a state of ongoing discussion (see IC), the question arises on how lessons learned obtain their structure during a LLCP.

A key instrument for creating case-specific lessons learned structures is simply the provision of guiding questions, e.g., in the form of a template or semi-structured questioning structure. If a case-specific lessons learned structure was defined (as in DP, DC, RC, TC) and communicated to the participants, this structure was followed (facilitated by the LLCP). The inverse also holds: if no lessons learned structure was provided (as an IC), the resulting lessons learned were unstructured as well.

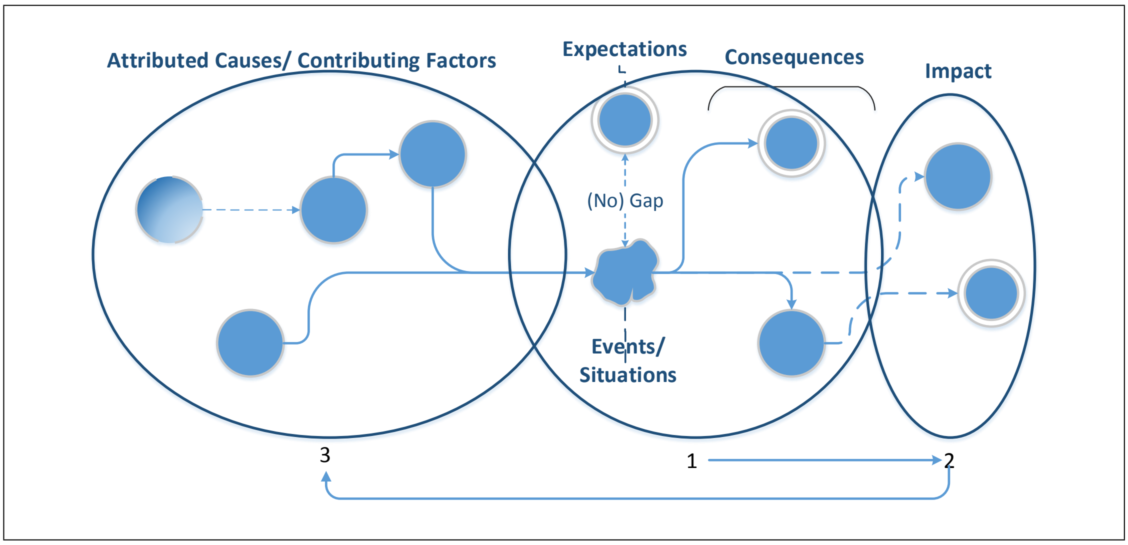

Figure 14.3: Eliciting a LL

Guiding questions are not equivalent to the meta-structure shown in Figure 13.1 on page 212. Rather, they add an order in which participants typically traverse the structure (see Figure 14.3 for the alignment of this flow with the meta-structure of lessons learned). The order from 1 to 3 suggested in Figure 14.3 indicates that participants start with communicating their experiences by moving from events to immediate consequences and experiences, then identifying high level impact, causes, and finally, recommendations (as observed in DC and DP, not shown in Figure 14.3). Iterations occurred, particularly between causes and recommendations, resulting in a causal network that could „grow into the past", depending on how far back participants decided to move with their analysis.

For semi-structured questioning, the order in which the components were addressed could change dynamically. For example, RP showed that participants could follow a flow from events to causes, and then to recommendations. They could also outline their lessons learned starting with the recommendations and then moving to effects and events.

Systematically covering part of the meta-structure through structured or semi-structured questioning resulted in participants stating causes and recommendations – thus they went beyond mere complaining or blaming.

There were three major choices made during the creation of a lesson learned. One is on the anchoring of the central event/situation in reality. Considering Figure 14.3 on the facing page, it would be possible to shift the structure to the right by denoting a consequence as the event/situation, and consider the event/situation itself as a cause. Another one is a decision on how far back (in a temporal sense) the causes[1] should go. Being responsible for a cause is not always a criterion, as the reflection on the boundaries of influences showed (see Section 13.2 on page 214).

The last one is the decision on how to place the recommendations. The analysis of the resulting lessons learned indicated that participants tended to formulate recommendations addressing early causes, and that the causes themselves seemed to form a directed graph. Interestingly, in DP, one early cause could be identified in several lessons learned, but was not addressed in the recommendation. Thus, participants do not necessarily attempt to address the first cause.

The influence of lessons learned structures on the resulting lessons learned are based on three underlying mechanisms. First, the observation of LLCPes in DC, RP, and DP, showed that the guiding questions were used as a frame shaping the *communication* on a content level between participants, or between participant and facilitator (with more or less room for adaptation in, e.g., a semi-structure questioning structure), leading to **directed elicitation**. The match between content and the template structure in TC and RC also indicates that the lessons learned structure shaped what the participants communicated.

Second, some components of a lesson learned structure seemed[2] to affect the *thought* process underlying the creation of a lesson learned, leading to **directed thinking**. For example, in RC, asking for expectations seemed to prevent participants from dwelling on the negative aspects of the project, and to turn a lesson learned towards an upward direction. Similarly, iteratively asking for causes might have expanded the frame in which participants constructed the problem (see RP).

Last, there are tentative indications that **individuals supporting participants** in creating lessons learned (e.g., a facilitator, moderator, or interviewer) mediate the relationship between participants and the conformance towards a given lessons learned structure. In the absence of a facilitator (as in RC) participants produced a higher number of lessons learned that were not following the provided lessons learned structure than in the presence of a facilitator (as in DP and DC). Also, the semi-structured approach used in RP ensured that major components of a lesson learned were addressed in the interviews, thought the interviewers ensured that the structures remained flexible. In TC, the structure was generally followed, but fields could be empty. Here, the macro-structure did not require all fields to be used. Thus, if something is not required, it might

[1] This is a key difference to any problem solving or decision making process: these processes have an implicit temporal boundary (the now) before which they cannot attempt to address a cause or event.

[2] Results on thought processes can only be tentative in this thesis, as the main observational focus was on communication and not thought.

not be created in the LLCP.

One explanation for the effect of individuals in supporting roles lies within the way deficiencies were handled during the elicitation of contributions (see Section 14.5). Another partial explanation for the influence of individuals in supporting roles has been outlined in Section 14.4.2 on page 232. It showed that individuals in supporting roles influence the filtering, organizing, and summarizing of contributions in a downstream phase, which provides an opportunity to fit contributions into a given lessons learned structure. However, there is no as actual evidence in this study on *how* was performed, and therefore, further research is needed to improve the understanding of this process.

Apparent **effects** of the approach to structure go beyond obtaining a structure for lessons learned. The questions seemed to help participants move beyond complaints towards a causal analysis and the development of recommendations, thus potentially addressing challenges associated with the analysis of experiences **Part4** to challenge **Part6** on page 64. It should be noted that even though this research established that causes and recommendations were elicited for almost all lessons learned (indicating a positive influence on *comprehensiveness*), a systematic assessment of the accuracy and usability of causes and recommendations was not part of this research.

14.5 Discovering Deficiencies in a Lesson Learned

The quality of a single lesson learned was predominantly checked by humans. Only RC systematically used simple automated quality checks.

The cases showed that non-automated deficiency discovery and fixing can be divided into five different approaches that varied with regard to who was responsible for discovering deficiencies (participants or individuals in supporting roles), and the timing of the discovery (immediate reaction; delayed, but in the same phase; separate phase of the LLCP, or even a different lesson learned process).

Participant/immediate. During collaborative discussions on a lesson learned participants could react to each other, allowing them not just to create the content for lessons learned, but also to correct misconceptions: participants from the client side corrected assumptions about what would be feasible for a client organization in DP, for example. Here, quality assurance required knowledge about the events in the project and the ability to judge recommendations or actions. Similar to this peer review process the moderator in TC and, to a limited extent, the interviewer in RP could also check the quality of the contributions using content-dependent feedback.

Supporting roles/immediate. In all collaborative cases the facilitator, interviewer, or moderator could provide immediate feedback during the LLCP, which was used for improving the quality of the contributions by using more general quality checks (e.g., with regard to understandability and comprehensiveness).

Supporting participant/same phase. The third approach was unique to IC. Here, the session owner deliberately checked the quality of contributions (both content-dependent and general), and asked participants to improve them. Unlike deficiency discovery in collaborative discussions or through the facilitator, this quality check happened with a slight delay, and seemed to compensate for the lack of feedback provided by the facilitator herself.

In contrast to these three approaches, the following two were used deliberately after the initial collection of lessons learned, and therefore in a separate phase or process

Participants/separate phase. The workshop-based approach dedicated a second meeting to improving extant lessons learned. In RP, this workshop did not just assess the participants' contributions, but also included a check on the analysis performed in the intermediary phase.

Verifier/separate LL process. Individual checks by dedicated participants (known as contact persons) or verifiers were used to finalize quality assurance. Due to the structure of DP and DC, this quality check was actually performed on the analysis delivered by the facilitator, and therefore aimed check the quality of the facilitator's summaries. In contrast, the quality checks in RC focused on the contributions of the initial author of a lesson learned and encompassed all the quality checks that, in a collaborative LLCP, were performed during the process. The verification process was, across cases, the only type of quality assurance that explicitly asked for a check on the uniqueness of a lesson learned (**Out3**).

To conclude, discovering and fixing deficiencies is, in collaborative lessons learned, a responsibility shared by individuals in supporting roles and participants. It aims to improve the quality of the collected lessons learned (**Out1**, including the alignment of the contributions with the case-specific lessons learned structure) and, through the verification process, filter out lessons learned that were considered less significant or duplicates of extant documentation (**Out3**). The approach to deficiency discovery is a key difference between RC, and the collaborative LLCPes: for discovering deficiencies during the same phase as the creation of the lessons learned RC only uses automated deficiency discovery with an existence criterion (i.e., is there some content in a text field) – the quality of the actual content is only checked through a verifier.

14.6 Basic Interaction Setting

Most cases systematically used a comparatively stable basic interaction setting specifying whether participants worked (a) in a (single) group, (b) in the same location, and (c) at the same time. Together, these three parameters influence who can react to whose contributions, and how much contextual information (e.g., on authorship of a contribution) and paraverbal content can be shared between participants *if* participants were allowed to interact. For single activities, this basic interaction setting was modified (e.g., removing interaction possibilities in voting).

Table 14.2 on the next page shows the basic interaction settings for the cases. In DP, DC, and TC this base setting can be best described as face to face collaboration (same time, same location). In TC, this involved sub-grouping (for dealing with **Env4**), while in DP and DC participants worked in one group. A modification of such a base setting in DP would be a removal of interaction possibilities (silent work), thus allowing participants to rate the project without being (directly) influenced or observed by other participants. In contrast, RC specified an open approach to the interaction settings (as participants could choose). However, in the actual LLCP, they presumably collected lessons learned individually (shown in Table 14.2 on the following page). RP and IC were the only two cases with mixed settings relating to location and time. RP used two settings – individual interviews without group interaction and a group workshop –

Table 14.2: Basic interaction settings across cases

	Group	Location	Time
DeepwaterCol & DepartmentCol	single group	co-located	same time
RepositoryCol (individual work)	no group	-	-
TerminationCol	single group / sub-groups / single group	co-located	same time
InnovCol – synchronicity version 1	self-organized sub-grouping	mixed (free choice)	same time
InnovCol – synchronicity version 2	self-organized sub-grouping	mixed (free choice)	asynchronous
RefineryCol – interviewing phase	no group	distributed	asynchronous
RefineryCol – workshop phase	single group	co-located	same time

one after the other (temporal division), while IC used a mixed approach based on the availability and preferences of participants. These two cases demonstrate that it is not necessary to use just a single basic interaction setting.

The basic interaction setting (supported by a GSS) in IC focused on an asynchronous, distributed way of working. As such, it was used to avoid scheduling conflicts, and to reduce potential conflicts with other work-related activities by reducing the time spend on a LLCP (see **Env3** and **Att2**). More specifically, the GSS was utilized to reduce traveling time through supporting work in a distributed group. RC was similar to IC in that participant could decide when they wanted to collected lessons learned. As a side-effect, IC and RC also gave participants the freedom to decide spending their time on activities not related to LLCPes. This might explain[3] the low participation in RC, and the need to specifically ask participants to make additional contributions in IC. This would constitute an inverse effect on **Env3** and **Att2**.

The variations in interaction settings also stem from the tension between combining multiple perspectives, and challenges that arise when combining multiple perspectives in collaborative LLCPes. Chapter 4 on page 45 has outlined potentially negative effects in perceived unsafe (group) environments (see **Part3**), difficulties in creating an open communication with the client **Part9**, and difficulties in dealing with larger project teams (see **Env4**).

Interviewing (in RP) and anonymity (in IC and RP) were used with the intention to create an open atmosphere without fear of negative repercussions (thus potentially addressing **Part3**), and, in RP, to handle conflicts between the organizations involved in the LLCP (potentially addressing **Part9**. Tracing of effects throughout the processes revealed that the interaction setting could indeed help to conceal who contributed something through the use of anonymity or interviewing (though for some contributions it might be easy for participants to identify an author based on the content of the contribution; see also Valacich et al. (1992) on low levels of anonymity). In this context,

[3] An alternative explanation would be that participants thought they had no (further) contributions, or that the contributions in the system were sufficient.

further research is needed to evaluate such variations in interaction settings on the participants' motivation and engagement in LLCPes.

14.7 Tool Support

Apart from supporting presentations or sharing information with the participants (e.g., in the opening phases of LLCPes), the tools used in the cases had two functions: keeping a record of the contributions made during the LLCP, and providing communication channels for the participants.

It is noteworthy that in none of the observed LLCPes, participants were using tools to access records of the project. In other words, the LLCPes (as far as could be observed) did rely on the participants' memory and knowledge, with exceptions pertaining to the information presented to participants in the opening phases of a LLCP, and in the reading activities in RC.

Also, tools were hardly used to create visualizations – neither visualizations of engineering solutions nor visualizations supporting the creation of a single lesson learned (such as causal diagrams) were supported (in activities other than the presentation of themes in the opening phase). This indicates a constraint in the selection of tools, but also in the selection of techniques when creating a single lesson learned.

For keeping a record of contributions towards the lessons learned, electronic or paper-based spreadsheets (found in DP, DC, TC), audio recorders (DP, DC, RP), a lesson learned application (RC), and group support systems (IC and RP) were used. In addition pen and whiteboard were used to keep a record of topics during the co-located LLCPes DP and DC. Using these tools indirectly influenced the content of the lessons learned. For example, writing down lessons learned without an audio recorder in RP would have resulted in a loss of information.

The communication support was used to enable some of the aspects of the interaction settings such as anonymity, and distributed locations. In some cases, tool support was the foundation upon which known challenges were addressed. A GSS (in IC and RP), and paper-based questionnaires were used to ensure anonymous communication (see Section 14.10 on page 243 for the potential influence of anonymity on motivation). In addition, the GSS was utilized to support the distributed setting in IC, thus potentially reducing the time spend on the LLCP (see **Env3** and **Att2**, and Section 14.6 on page 237).

14.8 Facilitation and Moderation of LLCPes

For all cases except RepositoryCol, facilitators or moderators guided through the LLCP, and influenced the intermediary and final outcomes by identifying potential deficiencies, and asking participants to fix these deficiencies (thus influencing the quality of lessons learned (**Out1**)). In DP, DC, and RP, they were also responsible for filtering, summarizing, and organizing of contributions, and, in RP and DC, were observed to contribute content to the lessons learned.

More subtle influences were exerted by indicating (and manipulating) the existence or lack of common ground between the facilitator and the participants (observed in

RP, DP, potentially addressing **Part2** for tacit knowledge that is comparatively easy to communicate).

Given this major influence on the outcome of the lessons learned, this section further analyzes who was chosen to facilitate a LLCP. A comparison of cases found a tendency to involve facilitators *external* to the organization collecting lessons learned. Exceptions were TerminationCol and DepartmentCol. Furthermore, all LLCPes had a facilitator external to the department or project collecting lessons learned, who was responsible for large parts of the moderation. Thus, the facilitators can be assumed to be *independent*: they had no direct interest in the content of the lessons learned, and often no stake in the project or main organization for which the lessons learned were collected.

In RefineryCol, the independence of the facilitator was used intentionally to address the conflicts and tension between the contractor and client. Here, RefineryCol provides first indications that, in addition to **Part9**, it can be challenging to deal with inter-group and interorganizational conflicts.

Facilitation and content creation were not entirely separated (DeepwaterCol being the exception). Cases varied on how this separation was broken. First, selecting independent facilitators did not entirely separate participants from being involved in the facilitation of LLCPes. In TerminationCol, the role of the facilitator was delegated to a participant (the moderator) who facilitated the actual collection of lessons learned as well as the development of actions for the next phase. Similarly, in InnovCol the session owner was responsible for deficiency discovery and fixing. Second, a facilitator's independence did not mean that they did not contribute to the content of lessons learned: both in DepartmentCol and in RefineryCol, the facilitator introduced own ideas in the discussion.

Considering this active involvement in content creation, there seems to be a tendency to involve individuals with *knowledge on the subject matters, organization, or project* in the facilitation. For comprehensive deficiency detection such knowledge might even be a prerequisite.

14.9 Participants

Participants exerted the key influence on the outcomes of a LLCP: they typically selected the topics for the lessons learned, and (usually orally) shared their experiences and developed recommendations for the lessons learned. In several cases, they were involved in creating additional information supporting the usage of a lesson learned, and some of the participants were involved in dedicated activities for improving drafted lessons learned.

Therefore, participant selection is an instrument used in the preparation phase with a high indirect influence on the collected lessons learned. The criteria for selecting participants do not just indirectly influence the content of the collected lessons learned, but might also impact the willingness to share certain contributions due to a lack of perceived safety (see **Part3**) and the credibility of the lessons learned (see Section 13.3 on page 215).

The cases showed that, for all LLCPes with the exception of RC, participants were intentionally selected – the collaborative LLCPes did not try to include the whole project or the whole department, and those who participated received an invitation to actually participate. In other words, participant selection was used as an actual instrument.

The cross-case workshop identified key characteristics of the selected participants that can be used as selection criteria. First, participant selection was dependent on whether a LLCP was based on a project or department (see Section 14.1 on page 223). For *department-based* LLCPes, participation was limited to members of the Department, and did not systematically include outsiders with whom Department members had to work together (though one member from another department was invited to DP). For *project-based* LLCPes, participant selection focused on members of the project team, but could also include individuals from the „fringes" of the project – those who were otherwise involved in the project (e.g., the program manager in RP). Within the project team, the selection included both technical experts and individuals concerned with the management of the project (observed in DP, RP, IC). As a consequence, the project-based LLCPes involved participants from a single project covering varying roles and areas of expertise, while department-based LLCPes were more uniform with regard to expertise, but did cover (and compare) multiple projects.

Second, the *theme* of a LLCP influenced participant selection. This could be observed, for example, in the participant changes between DP & DC one and two, where the group of participants changed to include experts on the respective theme discusses in the LLCP. There were also participants who were involved in DP I & II and DC I & II, respectively. For DP, this included participants from the client organization as well as the project manager/engineer. For DC, this included some engineers working on both themes as well as the Department head.

Another factor relates to the distinction between a core group (the project team or the department members associated with the team) and representatives of outside groups. For example, in RP, participants external to a core project team (such as the project managers manager in RP) were included with the aim to develop a wider picture on the experiences leading to a lesson learned. The benefit of this approach is perhaps best understood by looking at an example where a participant from the fringes of the project was not included: RP did not involve the business side in the LLCP, while the causal analysis indicated that the business side was involved in causal events leading to one of the lessons learned with the highest perceived impact on the project. As a consequence, the resulting lessons learned report was perceived as a one sided story – for the business side it seemed to lack credibility. For the other projects, the observations were not rich enough to make detailed observations. Nevertheless, the above example demonstrates that it can be beneficial to avoid missing perspectives by including individuals from outside a project.

Third, for project-based LLCPes *organizational associations* could be used to include or exclude participants. In RP, participants were selected from both project and contractor as both organizations played an important role for the performance of the project. In TC and DP, the involvement of both MarineOrg and its contractor (TC) or client (DP) might be explained by the expected potential continued cooperation between the involved organizations on the same or similar projects. In contrast, IC did not include contractors of the joint-venture in order to protect intellectual property. Nevertheless, as the project was a joint-venture, participants from varying mother organizations were involved. The findings on organizational associations stand in contrast to findings in the construction industry in the UK (see Carrillo (2005) and Paranagamage et al. (2012)) who found in their case research that involving representatives of clients or contractors was rare or less likely than involving members of the core project team. For department-based LLCPes, organizational associations seemed to be an implicit exclusion criterion, though, with just one department exploring lessons learned on a departmental level, further research is needed in this area.

Overall, there are two dominating patterns. First, participants were *selected for the whole LLCP* – a re-negotiation with the environment for involving additional participants did not take place. While this approach might be useful for the 2 hour LLCPes in DP, IC and RP were spread over several days. This might afford the opportunity to include additional participants (or remove participants) in later phases of a LLCP.

Second, participant selection was *oriented towards the past*: participants were selected based on their involvement in the events and situations discussed in the LLCP. Participants were not selected based on their expertise on the identified root causes or recommendations, perhaps because root causes and recommendations might not be known prior to the LLCP, and it might therefore be difficult to invite experts accordingly. The notion of limiting participation to those involved in a project is implicitly supported by literature on LLCPes: Schindler and Eppler (2003) suggested involving the project team and others involved in the project. Several studies found that core project team members as well as individuals on the fringes of the project were included (Koners, 2005; Paranagamage et al., 2012; Carrillo, 2005). Neither suggested involving participants who were not involved in the project but could make a contribution on causes and recommendations (with the exception of involving senior management (Koners, 2005)).

This orientation towards the past led to situations where experts on a topic were actually missing in the creation of recommendations or identification of root causes (which could exacerbate **Part6**). For example, lessons learned frequently dealt with softer issues while experts on these issues (e.g., on training or human resources) did not seem to be included in the LLCP. DC I & II did not involve individuals from tendering or project management in the LLCP. As a consequence, they developed recommendations for these actors without knowing whether these recommendations were feasible or acceptable.

Thus, involving outsiders based on their expertise might be beneficial. This notion is supported by literature. Researchers from the area of learning from failure (Cannon and Edmondson, 2005) suggest that involving carefully selected experts and systems thinkers might help to identify root causes, for example. Similarly, expertise matters when it comes to developing solutions to a problem (Voss et al., 1983).

The cases indicated two approaches for dealing with missing perspectives. In both approaches, the participants made assumptions about these perspectives (e.g., relating to what individuals could have done or could do), and developed recommendations. In the first approach, the participants also formed intentions to discuss recommendations with individuals (e.g., from the tendering department). In the second approach, they outlined several alternative recommendations by varying their assumptions (e.g., participants in DC varied cost and resource constraints when making assumptions about what would be acceptable for project managers).

14.10 Safe to contribute?

Discussing negative lessons learned across organizational boundaries or within a group of peers might reduce a participant's willingness to contribute due to expected negative repercussions for himself/herself (**Part3**) or his/her organization.

The latter concern involves considerations on whether discussing certain events and situations encountered in a project might have an effect on obtaining future projects with a client, for example.

Valacich et al. (1992) argued that anonymity allows group members to contribute without fear of (personal) repercussions. Anonymity through individual interviews (as used in RP) or enabled through a GSS (as used in IC and RP) (see Section 13.3 on page 215) might therefore help to reduce concerns about negative repercussions for a participant, and thus create a safer environment for the participants.

Nevertheless, anonymity as a mechanism for promoting a safe environment has limitations. Some individuals might be identifiable based on their prominent role in a project and the insider perspective they contribute to the lessons learned (e.g., the project manager). Similarly, anonymity might not alleviate concerns relating to the organization, as an organization is easier to identify based on their role in a project.

This analysis indicates that there is a tension between mechanisms used to improve a participant's willingness to contribute, and those used foster the credibility of lessons learned. Using anonymity can improve perceived safety, but reduces credibility, because the authority of the contributors is no longer identifiable. Conversely, involving multiple organizations improves credibility by creating a wider picture of events in a project, but reduces the willingness to discuss sensitive internal issues that could lead to negative repercussions for one's organization or that relate to intellectual property. So far, these considerations are theoretical in nature, as neither the perceived credibility nor the willingness of participants to contribute (and how safe they felt in contributing) were measured during the LLCPes.

14.11 Conclusions

Part II of this thesis developed an extended model of LLCPes, and applied it to decompose actual LLCPes into instruments such as techniques and their configurations, interaction settings, tools, and activities. This chapter builds upon these decompositions to identify salient variations on the instrument level, and to understand how these instruments shape the resulting lessons learned, thus providing additional insights into **RQ3**.

The results indicate that these instruments shape the collected lessons learned in two ways.

First, this chapter showed that they were part of a production process that shaped the intermediary and final outcomes of the process. The **set of lessons learned** (topics to include or exclude) was shaped through approaches reducing scope of the LLCP (moving from the project to the topics). The scoping of the LLCP (in conjunction with a time limit) reduced the quantity of collected lessons learned by eliminating themes or topics from the agenda. These approaches might have established a focus on content relating to how to work in a project (instead of knowledge on the created product), and established a focus on negative lessons learned.

LLCPes consisted of four types of steps that directly **shaped the content and structure of a single lesson learned** (see Table 14.1 on page 230). Depending on the case, two of these steps were exclusively performed in the verification phase. The results also showed that for several cases individuals in supporting roles had a direct influence on the process outcome, which stands in contrast to the assumptions outlined in the basic model. The most important instruments for actually shaping the contributions, and therefore the content of the lessons learned, were the criteria for participant selection, the approach (project or department-based LLCP), and the guiding questions for structuring the lessons learned.

The comparison of cases indicated that participant selection varied between a project and department-based approach, and was influenced by the theme of a LLCP as well as the organizational associations of a participant. Even though the cases showed that participant selection was consistently oriented towards the past, and did not vary during a LLCP, it was suggested that a more open approach (e.g., including some experts not involved in the project) might actually be beneficial for the development of root causes and recommendations.

Given the importance and effects of not using a lessons learned structure, LLCPes that aim to create lessons learned used by non-participants should use a lessons learned structure to guide through the process and to shape the resulting lessons learned. This structure can be used in a semi-structured way (as in RP) or more strictly. The results further showed that lessons learned structures were followed when provided. Thus, they might provide an opportunity to change the structure-related characteristics of the developed lessons learned. For example, the questions focusing on recommendations did not include any discernible attempt to develop recommendations that could be used (without preparation) in future projects after a problem had been encountered. If participants have a bias towards focusing on earlier causes (something that needs to be confirmed in future research), this lack of guidance might actually foster the focus on preventative lessons learned. Therefore, future research could explore how to create recommendations for a reactive instead of a preventative intervention.

Second, they might indirectly shape the outcomes by addressing the **challenges** outlined in Chapter 4 on page 45. While this chapter could identify how instruments potentially influence these challenges, a direct comparison of LLCPes with and without a certain type of instrument was often not found in the cases. Thus, the results in Box 14.1 can only be considered propositions. Further research is needed to understand to what extent these instruments address the challenges.

Box 14.1: On how to deal with challenges

Env3 Asynchronous, distributed interaction settings (enabled through a GSS) (in addition to approaches for dealing with Att2) might be used to reduce scheduling conflicts.

Env4 Two instruments allowed a LLCP do deal with larger projects: (a) dividing the potential content into several themes, and organizing one LLCP per theme, (b) working in sub-groups (as in TC). A GSS could also be used for this purpose, but none of the cases applied a GSS in this way.

Att2 Three instrument types were identified with the potential to *reduce the time spend on a LLCP*: (a) an approach for limiting the themes and reducing the number of topics (compared to an approach trying to collect all lessons learned for a project), (b) a facilitator (or another individual in a supporting role) documenting and summarizing oral contributions (compared to an approach in which participants have to themselves write lessons learned of similar extend during a discussion), (c) a GSS to support working from distributed locations (reducing travel time) and to support contributing in parallel might also reduce the overall time spend on the process.

Part2 Establishing common ground with an external facilitator might have helped to elicit more tacit knowledge.

Part3 Anonymity (towards other participants) was utilized to protect participants from negative repercussions. It was created through a GSS or through one-on one interview settings.

Part4, Part6 Guiding questions were utilized to help participants to move beyond identifying a failure towards analyzing causes and developing recommendations. However, focusing participant selection on the past might have the effect that experts for the causes or solutions were not present in a LLCP.

Part7 Utilizing a department-based approach to LLCPes reduces or eliminates the tendency to focus on a single project, which might improve the transferability of lessons learned to other projects.

Part9 Similar to Part3, one on one interview settings were used to allow participants to share their contributions freely.

Part10 Facilitators (or individuals in supporting roles) have been involved in assuring quality during a LLCP, and their interventions might help to create high-quality process outputs even though the participants themselves are initially not motivated to develop such outputs.

A comparison of the approaches to create a safe environment for participants also suggested that, in the presented cases, there was a tension between creating a safe environment to motivate participants, and obtaining credible lessons learned. Further research is needed to investigate whether this tension exists and how to address it.

Chapter 15

Conclusions

Project-based organizations collect lessons learned in order to improve the performance of projects. They aim to repeat successes by using positive lessons learned, and to avoid repeating negative experiences by using negative lessons learned. The introduction indicated that organizations can be ineffective in collecting lessons learned that are fit for this purpose.

To address this issue, this thesis focused on improving our understanding of LLCPes by answering three research questions:

- **RQ1**: *When are the collected lessons learned fit for their purpose?*
- **RQ2**: *What makes LLCPes challenging?*
- **RQ3**: *How do instruments used in LLCPes shape the resulting lessons learned?*

By developing answers to these questions, this thesis contributed to the development of knowledge and theory on lessons learned processes in particular, and organizational learning in general, which may in turn be used by organizations to improve their understanding of their own collection and usage processes, and to obtain ideas for introducing and modifying their own LLCPes.

RQ1 was addressed in Chapter 3 on page 33. Interviews and a literature study identified four general quality criteria (understandability, appropriate level of detail, quality/maturity of problem description, and the maturity/practicability of solutions, see also Box 3.3 on page 43) influencing whether lessons learned can be used for future usage.

More importantly, the content of a lesson learned needs to match certain characteristics of the usage process. Relevant characteristics of the usage process are the phase of Simon's (1977) decision-making process in which a lesson learned is used, whether lessons learned are to be used on an organizational level or directly in future project, and whether lessons learned are purely reactive (action was taken only after events or situations were re-encountered), or aimed to prevent problems/foster re-occurrence of positive experiences.

These characteristics of the usage process influence requirements for the content of the lessons learned, including the design space considered in the recommendations or actions outlined in a lesson learned. The decision-making phase influences if or at what level of maturity problem descriptions and potential solutions need to be outlined in lessons learned (see Table 3.2 on page 41). The usage on an organizational level (such as the development of modification of good practices) require lessons learned – including their recommendations and actions – to be usable prior to the start of a project, and to be generalizable to several projects (see Box 3.3 on page 43). For the usage in a project (see Box 3.3), it is sufficient for a lesson learned to be transferable to another project – the user of a lesson learned is responsible for checking the applicability and relevance of a particular lesson learned, and for adapting the recommendations to the project context.

On a project level, two situations have been differentiated (Section 3.4 on page 40). First, if lessons learned are considered early in the project, they can be used to prevent negative experiences from re-occurring or to react to the attributed causes or the events in a lesson learned in order to mitigate their effects. In this situation, both preventative and reactive recommendations can be useful. Similar considerations can be made for positive lessons learned. Second, if project members only look for lessons learned once they have encountered a problem or undesirable situation (as found by Newell et al. (2006)), they might find that they are too late to implement the recommendations or actions (see also Section 13.2 on page 214). Lessons learned that help them with reacting to the situation are, at least initially, more useful.

As a consequence of these variations, the quality of lessons learned or the success of a LLCP cannot be judged based on the outcomes of a LLCP alone. A lesson learned can be fit for purpose in one usage context, but entirely useless in another.

Chapter 3 limited the answer to **RQ1** to content characteristics of the lessons learned. The LLCP cases indicate that, in addition to these content characteristics, there are other factors associated with lessons learned that influence their usage and are influenced, in turn, by the LLCPes. First, Section 13.3 on page 215 proposed that source credibility is influenced by collecting lessons learned from a group, by consensus between participants, by additional verification, and by the authority or expertise of contributors. In turn, source credibility might influence a lesson's uptake, at least if their recommendations had not been implemented in the originating project. Second, variations in usage expectations influence whether lessons learned are fit for use. The evaluation in DeepwaterCol (in Section 7.4 on page 103) showed that participants and organizations might not be willing to use lessons learned other than in a usage processes communicated during (and around) the LLCP. In particular, using lessons learned on an organizational level instead of in a specified future project was not supported in the organization. Similarly, DepartmentCol showed that lessons learned might not be used if participants consider the LLCP to be an experiment that does not require further usage (see also Section 9.4.3 on page 144). In contrast, the expected usage was communicated in TerminationCol which ultimately resulted in a successful implementation of these lessons learned (see Section 11.5 on page 188). As a consequence, lessons learned might provide solutions for a problem at hand, or could prevent events from reoccurring in future project, but might nevertheless not be implemented due to a lack of source credibility or expectations that a particular type of usage is not required.

TerminationCol also showed that there is a potential interaction between quality criteria for lessons learned (such as the level of detail), and whether there is an overlap between participants in the LLCP and the usage process. TerminationCol produced the briefest lessons learned studied in this thesis, but, due to an overlap of participants, these lessons learned were successfully used in the TerminationProject (see Section 11.5 on page 188).

The answer to this question is limited in that only those factors were considered that can be influenced by a LLCP. This excludes, for example, usage situations in which the users' lack of trust in the lessons learned program prevents any lesson learned from being considered for usage.

RQ2: *What makes LLCPes challenging?*

Chapter 4 on page 45 systematically identified 20 challenges influencing the quantity, quality, percentage of unique lessons learned, and the ratio of positive to negative lessons learned (Section 4.7 on page 61 provides a detailed list and explanation of all of these challenges).

Four of these challenges can be considered ***things to avoid***. Mixing LLCPes with performance evaluations (**Att1**), using ICT systems that only allow participants to contribute a sub-set of their lessons learned (**Instr1** & **Instr2**), and using complex procedures for LLCPes (without training, see **Instr3**) all fall into this category.

Other might require interventions (***start doing***[1]) – without such interventions, LLCPes can fail or deliver poor results. These challenges vary with regard to the symptoms or effects they have on a LLCP. The organizational environment can *prevent LLCPes* from taking place (**Env1** and **Env2**), or *limit the resources* available for collecting lessons learned (**Env5**). Challenges associated with a LLCPes' environment (**Env3** and **Env4**) and the available time (**Att2**) influence *participant involvement*, that is who can participate in a LLCP and how much time they can spend on a given theme. Challenges associated with participants have two types of effects. Memory issues, difficulties in sharing tacit knowledge, motivational issues, restraints from including external stakeholders (**Part1** to **Part3** and **Part9**), and the motivation to produce high quality output (**Part10**) affect if and what kind of *experiences* participants *share*. Issues with establishing and maintaining a focus on the analysis of lessons learned, identifying work practices, establishing cause-effect relationships, and difficulties in creating general, transferable lessons learned (**Part4** to **Part7**) all affect how participants *process, analyze*, or *deal with* the experiences underlying a lesson learned.

These challenges provide a partial explanation for why LLCPes in organizations are difficult to perform. The things to avoid might help organizations to identify these bad practices, while the symptom-based view is a first step towards supporting organizations in identifying which aspects of their LLCPes need improvement.

The case research on LLCPes in Part II provides additional insights into three of these challenges. First, **Part9** is a more general challenge on how involving multiple organizations in a LLCP can influence what participants contribute (see also Section 14.8 on page 239). For example, RefineryCol provides first indications that, in addition to **Part9**, it can be challenging to deal with inter-group and inter-organizational conflicts.

The second insight questions the extent to which it is necessary to elicit tacit knowledge during a LLCP. There were lessons learned (e.g., in RepositoryCol, see Table 8.3 on page 120) that assumed that there was a match between roles and expertise of users and participants in projects, so that the users can use their own (tacit) knowledge for understanding and implementing a lesson learned. Alternatively, if discrepancies on a skill level were detected, participants could recommend developing or changing the

[1]The term 'start doing 'indicates that someone (e.g., a facilitator, project manager, participant) might need to start with an intervention in order to address such a challenge.

appropriate training or knowledge documents (with the actual development or change being made after the LLCP, found in DepartmentCol, see Section 9.3 on page 139). Thus, matching between a user's and a participant's expertise (and tacit knowledge), and deferral might reduce the need to elicit tacit knowledge during a LLCP.

Third, Tan et al. (2006) suggested dealing with memory issues by collecting lessons learned at the time that they occur. Such an approach might have negative consequences. The challenges on participant involvement indicate that it might be difficult to organize participants for a collaborative LLCP. Multiple participants/stakeholders are involved intentionally (as indicated in Section 14.9 on page 240). Tan's proposal could make the difficulties in involving participants more severe, resulting in a need to compromise in whom to include in a collaborative LLCP. Also, for the studied LLCPes, the participants discussed not just events, but also their consequences and their impact on the project (see Section 14.4.3 on page 234). Thus, if participants collect lessons learned 'live' (presumably referring to the event or situation), they might not yet have all the experiences that form the basis for a lesson learned, and that are the foundations for judging the importance of topics. There is no research investigating whether insights into consequences and the impact are available in a 'live' LLCP, and what the consequences for the use of lessons learned are.

RQ3: How do instruments used in LLCPes shape the resulting lessons learned?

Instruments shape the resulting lessons learned by influencing the participants' behavior (as proposed in the basic model in Section 1.2 on page 7, and shown in the cases in Part II on page 67). There are two types of influence that are relevant for this thesis. First, participants are directly guided in producing lessons learned through a LLCP. Second, instruments aim to create situations in which participants are not subject to liabilities that could deter them from collecting lessons learned. Such detrimental conditions were identified as part of the challenges.

Univariate perspective. The extended model suggested that abstracted LLCPes are complex instruments supporting participants in collecting lessons learned. Part II provided an in-depth description of several LLCPes used in the field, and indicated through tracing of the process (including intermediary results) that the abstracted LLCPes influenced the participants' behavior. Thus, abstracted LLCPes are instruments that have an indirect influence on the resulting lessons learned. The cases indicated that, in facilitated LLCPes, the guidance and restrictiveness provided by the facilitator (and optionally any moderators) in combination with written instructions might have mediated the effects of the abstracted LLCPes.

The discussions and conclusions of the collaborative LLCPes showed that the quantity of the lessons learned, the themes addressed in the lessons learned, the (case-specific) structure or semi-structure of the lessons learned, as well as their level of detail were influenced by the abstracted LLCPes. For example, TerminationCol resulted in lessons learned focusing on actions (not recommendations), while InnovCol led to lessons learned without any discernible structure (or clear recommendations). Both LLCPes covered several themes, while DepartmentCol had a more narrow scope in collecting lessons learned matching a single theme. In contrast to the collaborative, facilitated processes, RefineryCol influenced the structure of the lessons learned, but no influence on the topics (beyond selecting participants for the pilot phase) or level of detail could be identified. When transferring the abstracted LLCPes to similar collection opportunities, these effects might therefore reoccur.

DeepwaterCol I & II, DepartmentCol I & II, and RepositoryCol showed that abstracted LLCPes can be transferred to other collection opportunities, and the transfer between DeepwaterCol and DepartmentCol indicates that DeepwaterCol can also be adopted and adapted by other facilitators. From a practical point of view this implies that the LLCPes might be usable in similar contexts to those in which the LLCPes were originally used.

Not all LLCPes presented in this thesis seem to be suitable for every collection opportunity or targeted usage process, though. Rather, the abstracted LLCPes might be specialists, not generalists. For example, TerminationCol is an abstract process that might require participants who are also involved in the usage process, while DeepwaterCol did not make such assumptions. A LLCP using a semi-structured group discussion without anonymity for collecting lessons learned might The results further indicated that the abstracted LLCPes do not lead to lessons learned that are fit for all usage processes (see Section 13.5 on page 219). Rather, all studied cases had systematic gaps in their coverage of usage processes. They did not reliably collect lessons learned on the products of a project, or collected positive lessons learned. The collected lessons learned also influenced when and for whom a lesson learned would be useful.

Inside LLCPes. Considering LLCPes as a single, independent variable does not help to develop an understanding of the effects of components of these LLCPes such as activities or techniques. To address this shortcoming, Chapter 14 on page 222 identified salient components of the LLCPes, and proposed how they influence the collected lessons learned, and how they address some of the challenges associated with LLCPes.

The reflections in Section 14.2 on page 223 showed that there were two instruments providing direct active guidance: the lesson learned structure (which shapes the final structure, and influences the components of a lesson learned considered in the collection process, and the structure of the LLCP.

The former specified which particular structure a lesson learned should have, and typically distinguished between a description of the past (in the form of events, impact, causal attributions, for example), and a solution part (suggesting recommendations or actions). The LLCPes varied with regard to commitment towards these solutions: in TerminationCol, the participants made decisions on which actions to take and followed through with it, while the other LLCPes remained on a level of suggestions (in the case of actions handing them over to individuals who can decide whether they should be implemented).

The latter contained elements for scoping (moving from project to particular topics to discuss), and four steps for collecting a single lesson learned that were typically present in the cases (see Section 14.4 on page 225 for details). In contrast to studies of PMEs (see Kasi et al. (2008)), these steps did not include collecting or accessing project documenting. Instead, LLCPes studied in this thesis seem to rely on participants and individuals in supporting roles to contribute such data. For one of these steps, the collection of contributions for a lesson learned outlined in Section 14.4.3 on page 234, the thesis identified a shared underlying macro-structure for the lessons learned (found in all cases with the exception of InnovCol, which did not organize contributions into a lessons learned structure; see Section 13.1 on page 212 for the structure), and showed that participants tended to move through that structure in a specific order (with options for iterations, and later additions) when making initial contributions for each component of the structure. The cases further indicate that quality assurance is a cross-cutting concern performed both throughout the LLCP, and as dedicated activities (see Section 14.5 on page 236). In contrast to the basic model, the results on these four steps show that participants are not the only individuals contributing to a lesson learned. Instead, facilitator and individuals in supporting roles can have a direct influence on the lessons learned (see Section 14.4.2 on page 232). This influence exerts to filtering and organizing contributions, and summarizing them into lessons learned. Less typically, facilitators also make contributions to the lessons learned, e.g., in the form of suggesting causes.

Traceable indirect influences on the LLCP were exerted through two choices in the preparation phase: theme selection (see Section 14.4.1 on page 225) and participant selection (Section 14.9 on page 240). The case results show that theme selection influenced the topics of the lessons learned, and informed the selection of participants. Participants were selected for the whole LLCP, and, if lessons learned were collected from a project instead of a department, included participants associated with several stakeholders of the project. Importantly, participant selection was predominantly oriented towards the past (who can contribute to the events, situations, their consequence, and their impact), and did not include external experts on the causes or recommendations.

Challenges. Box 14.1 on page 244 proposes several instruments that could influence participant involvement, the sharing of experiences, and the processing of these experiences. Important for preventing or mitigating these challenges are aspects of the interaction settings (particularly anonymity and distributed working), theme selection and distribution across LLCPes, and the decision on who should facilitate, and what the tasks of the facilitator should be.

Box 14.1 does not cover all challenges. Due to the case selection, the samples were biased towards (semi-)successful LLCPes. Also, the case boundaries focused on the main phase of the LLCP, with limited data on the project or the preparation phase. As a consequence, planned LLCPes that did not take place, limitations to instruments discussed in the preparation phase, or potential participants who declined to get involved in a LLCP could not be researched. Similarly, insights into psychological processes were limited. Last, challenges listed as things to avoid were not encountered in the cases.

DeepwaterCol and InnovCol were performed because the project client and organizations financing the project made it part of the contracts. Thus, there was external pressure on the project and the project organization to perform a LLCP. This finding is in line with Carrillo et al. (2013); Wiewiora and Murphy (2015) who found that project-based organizations face demands from clients to demonstrate that they learn from project. However, the case selection for this thesis was focused on LLCPes that actually took place, and therefore any insights into the reasons of an organization for conducting a LLCP are biased (i.e., there are no insights on whether projects with similar agreements would find ways to not perform a LLCP).

Not shaped through LLCPes. Some characteristics of the final lessons learned could (consistently) not be attributed to the abstracted LLCPes and their components. These characteristics included some of the choices made during a LLCP: what to focus on as the main event, what to focus on in the recommendations (undoing identified causes, dealing with events, or reducing the impact of causes, for example), and determining which roles recommendations should target. The focus on a project's process (instead of its product) only partially matches the instruments employed in the LLCPes. While several LLCPes asked participants to discuss process-related aspects such as supply chains, others did not suggest themes (RefineryCol) or gave a theme that lent itself to lessons learned on both process and product. Nevertheless, the resulting lessons learned had a tendency to focus on the process, not the product. Last, the collected lessons learned were typically negative, even though all LLCPes with the exception of TerminationCol explicitly asked for positive lessons learned. This observation also holds for LLCPes with a positive atmosphere (DepartmentCol), and one in which identity could be kept anonymous, thus creating a safe environment (RefineryCol). Altogether, this indicates that the abstracted LLCPes are not influencing the ratio of positive to negative lessons learned in such a way, that a balance between these two types can be achieved (unlike the LLCP proposed by Baaz et al. (2010)).

15.1 Limitations

The researcher's perspective. This research was conducted from a systems engineering perspective. This perspective, as well as insights from project management, and concepts and theories outlined in the basic and extended model, have informed the research question and have resulted in a focus on the design and effects of LLCPes in project-based organizations. For understanding how the usage of lessons learned and LLCPes fit together, theories of organizational decision making are used as well.

Methodology. Another limitation lies in the research approach. In terms of critical realism, this thesis focuses on intensive research, that is, it aims to create an in-depth understanding of a few LLCPes by studying multiple cases. As a consequence of the case research, results have a high ecological validity but lack control (e.g., in comparison with lab experiments), and take into account the open nature of lessons learned processes. However, patterns and relationships identified in this research are not representative, and only have a limited generalizability. The results focus on existence rather than on prevalence. Nevertheless, by including several cases, the challenges, insights into fitness for usage, and results on LLCPes obtained in the cross-case reflections are not limited to a single organization or project.

Case selection. This thesis focused on LLCPes in the oil and gas industry in North-Western Europe (primarily the Netherlands) that were used in projects following a classical project management approach. As such, the results for the LLCPes, but also the challenges, and the insights about the usage processes might be limited to cultures in this region, and to engineering domains (or to participants with matching backgrounds) with similar project characteristics. To give an example, the results might be applicable in large construction projects in the Netherlands as well, but it remains in interesting question to what extent they transfer to software development projects using an agile project management approach.

Another limitation stems from the maturity of the lessons learned programs in those organizations in which the studied LLCPes took place. The conceptualization of lessons learned and the attitude towards this concept could not be systematically studied in this thesis. However, given the immature lessons learned programs in most case organizations, it might be that the employees did not have a strong negative attitude towards lessons learned, or a shared conceptualization of lessons learned and LLCPes.

The results of the LLCPes cases, and the cross-case reflections might therefore not be valid in environments where (potential) participants had such negative attitudes, or where they had an understanding of lessons learned deviating from the open ones used in the LLCPes.

The type of product created in a project might be an important limitation that requires further attention. The products studied in this thesis all revolve around large physical constructions or installations in the oil and gas industry, though DepartmentCol also includes services needed to create such a product. In this context, it might be interesting to explore to what extent the results in this thesis are applicable to projects with different types of products, such as services (instead of physical products), and to novel products (e.g., in R&D projects).

15.2 Future Research

The research in this thesis improved our understanding of lessons learned, and the design of LLCPes. This improved understanding has opened up avenues for further research. In the following, this section presents a selection of future research that might help to further understand and improve lessons learned efforts.

Challenges. Organizations or individuals aiming to collect lessons learned might encounter the challenges identified in this thesis, and thus need to deal with them. To support organizations with this task, two lines of research are needed. First, organizations need to be able to identify whether a particular challenge applies to them. To support organizations with this task, a diagnostic framework identifying intermediary symptoms and their likely causes might be useful (similar to Rheinberg's (2004) motivational framework). In this context, future research might also improve the theoretical basis of the challenges by (a) checking the relevance of these challenges (e.g., what types of tacit knowledge, if any, are both relevant for lessons learned and difficult to articulate), and (b) adding literature dealing with foundational processes including cognitive challenges (such as memory issues and biases in counterfactual thinking) and group challenges (such as dominance of individuals in discussions, majority issues in voting, and social loafing).

Knowing whether certain causes and symptoms are relevant for an organization or a particular LLCP does not yet mean that these challenges can be handled. Thus, a second line of research could build upon interventions proposed in Box 14.1 on page 244 by investigating which interventions are effective in preventing or mitigating effects of these challenges, and what their interactions with other variables prevalent in a LLCP are (preferably without introducing other severe negative consequences; aim: allow facilitators and other decision makers to make informed choices).

Usage. This thesis focused on the design of LLCPes. However, for lessons learned to improve the performance of future projects, organizations do not just need LLCPes, but also processes for using lessons learned. One line of research in this context might focus on such usage processes. Chapter 3 on page 33 indicated that usage processes, like LLCPes, can include collaborative facilitated processes. Lessons learned might also be useful for developing good practices (as one form of using lessons learned on an organizational level). Last, Section 13.4 on page 217 proposed that lessons learned from past projects might be risks in future projects. Thus, the design and evaluation of such usage processes might be one avenue for future research. Another avenue might utilize the methodology used in this thesis to explore how lessons learned are used in project-based organizations.

LLCPes. The research presented in this thesis provided a partial answer to how instruments shape the resulting lessons learned, and identified two key structures in LLCPes. A key question for future research pertains to the effects of changes in instrumentation. For example, future research may change the design of LLCPes (including changes in techniques and their configurations) presented in this thesis to address some of the challenges or particular usage requirements (e.g., change the process in such a way that they consistently collect product knowledge or so that recommendations can be used to react to an event without preparation). Also, some of the things that seemed to be kept constant across cases might be interesting to change. Instead of selecting participants based on their involvement in a past project, some participants may be included based on their expertise and independence from the project (maybe only for part of the LLCP), for example.

In addition, the cross-case reflections on LLCPes focused on salient instruments used as part of a LLCP. This excludes some instruments, such as the ground rules, theme presentations, or the way goals of the LLCPes are communicated. Also, the effects of variations in techniques or their configuration deserve further attention (e.g., how would changes in rating techniques affect topic selection, and how does it interact with participant selection?).

Effects of LLCPes. There is a need to develop a framework for understanding and measuring the effects of LLCPes, with two aspects that are particularly important. First, this thesis focused on the product created in a LLCP (in terms of lessons learned). This focus should be expanded to include process-related factors such as participant satisfaction, and to include other effects on participants that might be relevant when an organization attempts to develop a mature lessons learned program (such as effects on an understanding of what lessons learned are, or effects on the attitude towards lessons learned, and expectations on how lessons learned should be used). Second, such a framework needs to consider how to evaluate the actions and recommendations proposed in a lesson learned. This thesis raised questions about the suitability of recommendations for particular usage types (see Section 13.3 on page 215), and research on the effects of LLCPes should be capable of detecting, e.g., if and by whom lessons learned are considered impractical (see also Section 13.5 on page 219).

Integration of usage and LLCPes. One limitation of this research is that the lessons learned collected in the studied LLCPes could not be observed in their usage. This limits the evaluations of the LLCPes as well as the insights obtained for **RQ1**. For example, this thesis could not study how lessons learned could or needed to be adapted during the usage process. Also, the evaluation of LLCPes might profit from an integrated approach. Thus, future research may address this issue by developing and applying research designs that include an integration of LLCPes and usage processes while still approximating the real-world contexts in which lessons learned are collected and used. Such research designs may be longitudinal studies, but might also include more controlled settings such as simulations.

Beyond the case selection criteria. The univariate perspective on LLCPes included a discussion on what kind of effects to expect when transferring the abstracted LLCPes to other, similar settings. In this context, further research is needed to investigate whether the propositions made in the case chapters hold in different case settings. It might be interesting, for example, to apply abstract LLCPes utilizing anonymity in organizations with a fear culture. Last, future research might explore the applicability of the results obtained in this thesis beyond the case boundaries outlined under limitations (Section 15.1 on page 252). This includes research transferring the LLCPes to other domains in which lessons learned are relevant (such as the construction industry) or to domains focusing on different products or services (such as academia or the health sector). Also the influence of national cultures on LLCPes might be worth investigating (starting with the USA).

Appendix

Appendix A

What is a Lesson Learned?

Table A.1: Definitions of lessons learned

Source	Definition	Category
Harrison (as cited by Gibson et al. (2007))	"A good work practice or innovative approach that is captured and shared to promote repeat application, or an adverse work practice or experience that is captured and shared to avoid recurrence."	Behavioural (focus on actions) and Cognitive
Swan et al. (2010)	one mechanism to support learning within or from projects	Classification
Bickford (as cited by Weber et al. (2001))	"A lessons learned is the knowledge acquired from an innovation or an adverse experience that causes a worker or an organization to improve a process or activity to work safer, more effciently, or with higher quality (Bickford, 2000a)." [emphasis removed]	Cognitive
Gibson et al. (2007)	"Knowledge gained from experience, successful or otherwise, for the purpose of improving future performance. Examples include: • A lesson learned that is incorporated into a work process • A tip to enhance future performance • A solution to a problem or a preventative action • A lesson that is incorporated into a policy or a guideline • An adverse situation to avoid" [emphasis removed]	Cognitive

Continued on next page

Table A.1 – continued from previous page

Source	Definition	Theme
Keegan and Turner (2001)	"All of the companies we studied, without exception, have practices in place to try to capture the learning that takes place on projects when these projects are completed. The purpose of these practices is to capture the lessons learned on projects, codify them, and make them available to other members of the organization."	Cognitive
Liebowitz (2008)	"A 'lesson learn' can be a success or a failure. It is an understanding or experience that might want to be shared by others."	Cognitive
Project Management Institute (PMI) (2004)	"Lessons learned [output/ input] are the learning gained from the process of performing the project. The focus of lessons learned can vary. In some cases, the focus is on strong technical or product development processes, while in other cases, the focus is on the processes that aided or hindered performance of the work."	Cognitive
Schindler and Eppler (2003)	"Lessons learned are defined as key project experiences which have a certain general business relevance for future projects. They have been validated by a project team and represent a consensus on a key insight that should be considered in future projects."	Cognitive
Space Agencies (as cited by Weber et al. (2001))	"A lesson learned is a knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. Successes are also considered sources of lessons learned. A lesson must be significant in that it has a real or assumed impact on operations; valid in that is factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result."	Cognitive
US Army (as cited by Gibson et al. (2007))	"validated knowledge and experience derived from observations and historical study of military training, exercises, and combat operations"	Cognitive
Kasi et al. (2008)	"[...] post mortem evaluation (PME) has long been advocated as a means of improving development practices by learning from IT project failures [...].", "In theory, PMEs can help individuals and organizations learn what worked and what can be improved upon so that lessons learned in one project can be applied to future projects."	Object in Process
Baaz et al. (2010)	"a [. . .] tradition of reviewing projects to learn from mistakes, a process called lessons learned or postmortem evaluations"; "lessons-learned theory suggests we should learn from what was right as well as what was wrong"	Process itself

Continued on next page

Table A.1 – continued from previous page

Source	Definition	Theme
Von Zedtwitz (2002)	"We define a post-project review as the final formal review in the course of a project that examines any lessons that may be learned and used to the benefit of future projects."	Object in Process
Cacciatori et al. (2011)	One output of a knowledge codification effort	Text
Disterer (2002)	"One possible form to capture the result of such reflection are so called 'lessons learned'. This special documentation covers the full and detailed, descriptions of the identification and the solution of concrete and detailed explained problems, which can be used as examples for following projects. The questions raised and discussed during reflection and documented in lessons learned can cover technical issues, organizational aspects or special social situations. The description should also include failed approaches and approaches which are not chosen for implementation."	Text
Raelin (as cited by Newell et al. (2006))	"project members are asked to capture the knowledge and learning from their project in the form of 'lessons learned'"	Text
Stewart (as cited by Weber et al. (2001))	"guidelines, tips, or checklists of what went right or wrong in a particular event"	Text
US Airforce (as cited by Weber et al. (2001))	"A lesson learned is a recorded experience of value; a conclusion drawn from analysis of feedback information on past and/or current programs, policies, systems and processes. Lessons may show successes or innovative techniques, or they may show deficiencies or problems to be avoided. A lesson may be: 1. An informal policy or procedure. 2. Something you want to repeat. 3. A solution to a problem, or a corrective action. 4. How to avoid repeating an error. 5. Something you never want to do (again)."	Text about cognitive entity

Appendix B

Quality of LL

B.1 Understandability

Understandability of a (written) text can be defined as the ease with which a reader can read and understand it. It is dependent upon the reader as well as the document (Folker, 2011).

The variables associated with the reader are

- Motivation & Interest
- Prior knowledge (!)
- Intelligence
- Reading skills
- Fluency
- Level of education

Variables associated with the document are

- Content
- Visualizations (illustrations, diagrams, ..)
- Structure and organization of the text
- Leserbezug
- Readability (e.g., measured with the Flesch Reading Ease test)
- Typography

B.2 Specificity

Specificity (or the lack thereof) has several different aspects. The following lists present first ideas on what specificity entails:

For objects:

- (natural) categorization of concepts: ingredients for apple pie - apple - Breaburn (all categorizing a particular apple)
- subsets created through attributes
  - by adding a referent: consequence versus consequence for the environment
  - by adding adjectives, e.g., a schedule driven project versus a project
  - by using (linguistic or numeric) scales: a better cable versus the cable
- type-token distinction: Mr Smith (as a token of the type) - a project manager (as the type)
- numerical references: absolute numbers - categorizations (a little, a lot, 50%) - no numbers
- directions (also in combination with numerical references): no direction (budget) - direction (over budget) - extent of direction (50% over budget)

B.2.1 Breaking up a Composite

Describing the whole versus describing the parts

Doing things/activities:

- from task goal to implementation guide: build a team (task) versus high level approaches versus detailed instructions for building a team (implementation guide containing team building exercises, ...)
  - breaks tasks down into steps

Detailed descriptions of situations and events?

- increasing the number of objects used to describe a situation (adding details)
- break down an event into stages, ...

Appendix C

LeafHopper Technique

The following description of the technique is a shortened version of the technique described by Briggs and de Vreede (2009).

Summary Participants add contributions to several topics X_1 to X_n (see Figure C.1) or comments on extant contributions. All contributions should be within a scope of the main prompt Y. Each topic X_i, $1 <= i <= n$, can be contributed to independently of the other topics. Each participant „hops" among the topics, choosing the next one based on interest, expertise, and available time. There is no expectation that a participant should have read contributions from or contributed to all topics.

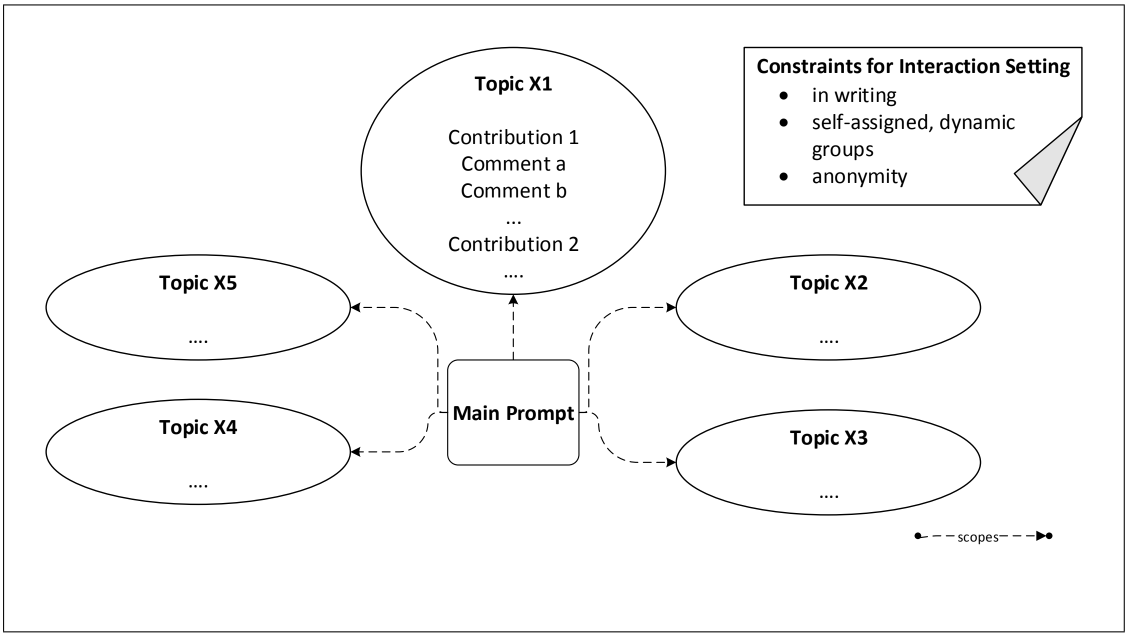

Figure C.1: Example of a LeafHopper with 5 topics.

Instructions should

- explain the topics X_1 to X_n, and the main prompt Y
- explain how to use the tools, if necessary

- explain how to contribute (see summary)
- stress the free choice of topic(s) based on interest and expertise
- stress that participants do not have to work on every topic (e.g., because of limited available time)

Criteria for selecting this technique

- participants need to contribute to several topics
- it is not important that every participant contributes to every topic
- participants have different interests or areas of expertise

Appendix D

Research Design

D.1 Data Collection for LLCPes in MarineOrg

D.1.1 Instrument C1: Observing Facilitated LLCPes

One objective in designing this research instrument was to create a *manageable* instrument, resulting in two design choices. First, the instrument uses a *limited* set of observational categories (and not the complete extended model[1]) (see Box D.4 on the following page). These categories focus on understanding how an activity is performed. For each activity, intermediary results as well as facilitator and participant communication in the context of these activities are considered. Even though some concepts of the extended model are not represented in research instrument 1, the research instrument still ensures that these concepts are addressed. More specifically, the facilitator's instructions provide insights into techniques and their configurations, as well as into dynamic interventions targeting the quality of contributions (see also Kolfschoten et al. (2011) for the relationship between the facilitator's communication, quality assurance, and participant behavior). Second, the instrument explicates assumptions about the interaction setting in a face to face workshop environment (Box D.1 on the next page), and then focuses the observation on *changes* made during the LLCP.

As a first step during the workshop, the actual setting was noted (Box D.2 on the following page). During the main phase, the process was broken down into activities. The temporal delineation of activities was a key challenge in the observation (and analysis) of LLCPes. The indicators presented in Box D.3 on the next page were used to tentatively demarcate the temporal borders of an activity. In addition, a comparison of purposes across cases were used to delineate activities.

[1] Another reason for not using the extended model was that the model was still under development at the time the observations were conducted.

Box D.1: Instrument C1 / Part 1 – Assumptions regarding the main interaction setting

- Group work: yes
- Expression mode: verbal
- Anonymity: no
- Interaction among participants: yes
- Sub-grouping: no
- Simultaneity: turn taking / discussion
- Relative location: co-located

Box D.2: Instrument C1 / Part 2 – Observational framework to analyze the setting of the workshop

- Room layout & seating arrangements
- Physical tools (e.g., screens, flipcharts, whiteboards, . . .)
- Deviations from assumptions about the main interaction setting

Box D.3: Instrument C1 / Part 3 – Indicators for demarcating activities during observation

- the group works on a new agenda point
- the main speaker changes (e.g., from facilitator to presenter)
- the interaction setting changes
- the facilitator gives new static instructions
- activities may be separated by breaks
- starting to work on a new (physical or informational) artifact

Box D.4: Instrument C1 / Part 4 – Observational framework for an activity

Techniques: focus on how an activity is performed. Examples include quick-round, presentation, (group) discussion, Q/A, and voting techniques (requiring detailed notes on voting procedure).

Interaction Setting: additional changes not implied by changes in techniques

Duration of activities: Note time-stamps when a new activity starts (only when there is enough time between notes; particularly for the introduction involving multiple slides, the focus was on the content, and not on the duration per slide)

Written information: includes content of (prepared) power-point presentations, notes taken down on a whiteboard (indicating intermediary results), and observations about information continued to be displayed during the following activities

Facilitator: instructions, questions & noteworthy behavior

Participants: (a) information about their affiliations and roles, (b) unexpected behavior (expectations are formed based on the instructions of the facilitator), (c) notes on the content of the discussion (for alignment with process output)

Positive versus negative LL : any indication by participants or facilitator on whether they are communicating about positive or negative experiences

D.1.2 Instrument C2: Pre-Pilot Interview in MarineOrg

The following interview guide was used prior to the pilot in MarineOrg. It uses a short overview of the lessons learned process It focuses on past experiences with lessons learned, and allows forming expectations about the pilot phase and lessons learned.

Box D.5: Instrument C2: Prompt used during pre-pilot interview (MarineOrg)

Parts of the lessons learned process

- Capturing: Sessions and lessons learned template (for editing and reading)
- Verification (through checklist)
- Decision on Action (through checklist and further implementation)
- Retrieval of lessons learned: reading through specific lessons learned, e.g., after accessing overviews of lessons learned (e.g., for RepositoryCol), RSS Feeds, and search functions
- Reuse of lessons learned

Box D.6: Instrument C2: Interview guide used during pre-pilot interview (MarineOrg)

Introduction:
Introduce lessons learned process and what is done during the pilot (using the prompt). Ensure that the first three process steps are clear.
Perceptions and expectations regarding lessons learned and the lessons learned processes:

- Have you ever encountered such a lessons learned system in the past, or worked with lessons learned in the past?
- What were the biggest challenges there?
  - Alternative: what do you think will be the biggest challenges for the lessons learned process? (for interviewees with little personal experience)
- In your opinion, what makes up a good lesson learned?
- What do you see as a benefit/big chance of the pilot?
- What is the biggest challenge in the lessons learned pilot?

(Potential) Behavior during the pilot phase:

- Which of these process steps do you think you will be involved in?
- How much time do you expect to spend on it?
- Could you name 3 to 5 topics that might come up in the lessons learned (during the pilot phase)?
  - What will you be working on during the pilot phase? (alternative, if interviewee is not willing to guess)

D.1.3 Instrument C3: Final Interview MarineOrg

The purpose of the final interview at MarineOrg was threefold:

1. to gain insights into the process quality of the lessons learned processes (including their usefulness, benefits and drawbacks) (see Box D.7 on the following page)

2. to obtain information on the actual usage of lessons learned from the various cases (see Box D.8)

3. to follow up on missing information regarding the cases (see Box D.7)

Box D.7: Instrument C3.1: Obtaining insights into process quality of the lessons learned processes

For each process:

- What is the current (or planned) status of the process? (not used anymore, continued usage with or without modification, limited usage, . . .)
- What was modified, and in which way? **Why**?
- Failed attempts: were there any things that you try, but that did not work out?

The following processes should be covered in depth: the collection through the repository, the facilitated sessions used in DeepwaterProject and DepartmentCol, and (to a lesser extent) the session observed in TerminationProject. In addition, the verification process and usage processes were addressed.

The following questions provided more explicit probing (if needed):

- What were challenges and issues with the process?
- What are the benefits? What worked well?
- What were drawbacks? What needed improvement?

General questions:

- Did you add processes to the overall LLCP? What about training?
- What is the value of lessons learned for MarineOrg (today)?

Box D.8: Instrument C3.2: Interview questions exploring how lessons learned were used

- What was done with the collected lessons learned?
- How were the lessons learned used? (if applicable)
- What about [intended usage of lessons learned]?

Box D.9: Instrument C3.3: Interview questions for obtaining missing information on LLCPes (MarineOrg)

- Culture: How does culture influence the collection of lessons learned in MarineOrg?
- Access: Who has access to the software application, and the collected lessons learned? Are there limitations for offshore access?
- How does the formal roles and responsibilities concept look like?
- Do you have blaming during the LLCPes? How do you deal with it?
- How many LL have actions, and how many LL should have actions?

D.1.4 Survey[2]

D.1.4.1 … prior to the pilot phase in MarineOrg

Box D.10: Announcing the survey to DepartmentCol I & II prior to the pilot phase

Dear All,

[Name of Department Head] and I are currently arranging a lessons learned session on [technical topic] for which you will be invited.

For this topic we will be piloting a new lessons learned application to demonstrate its added value. If the pilot is successful, we hope to roll out the lessons learned application this year.

This pilot will be evaluated by the faculty of Technology, Policy & Management TU Delft. The first part of this evaluation is for all people taking part in the sessions to fill in a questionnaire on the current situation of lessons learned.

You are therefore kindly requested to participate in this questionnaire. Please note, that for timekeeping purposes you can use [code].

This week Tanja Buttler (TU Delft) will send round the link to the questionnaire. If you have any questions on the contents of the questionnaire, please contact Tanja Buttler (T.Buttler@tudelft.nl).

Thanks in advance,

Regards,

[Name of Knowledge Manager at MarineOrg]

Box D.11: Announcing the survey in RepositoryCol prior to the pilot phase

Dear All,

As you know we will be piloting a new lessons learned application to demonstrate its added value. If the pilot is successful, we hope to roll out the lessons learned application this year.

This pilot will be evaluated by the faculty of Technology, Policy & Management TU Delft. The first part of this evaluation is for you fill in a **questionnaire** on the current situation of lessons learned. You are therefore kindly requested to participate in this questionnaire. Please note, that for timekeeping purposes you can use [code]. This week Tanja Buttler (TU Delft) will send round the link to the questionnaire. If you have any questions on the contents of the questionnaire, please contact Tanja Buttler (T.Buttler@tudelft.nl).

As of **Monday** you can **start using** the lessons learned application to submit your lessons learned. The application has now been „frozen": e.g., no more changes will be made. In the next few weeks if you run into things which you think are inefficient, annoying, unclear etc. please send me an email or come discuss it with me. We can then implement these improvements when we have the next revision. This next revision will most likely be end of May/beginning of June in which a newer version of SharePoint will be available. Of course if there are errors, or if you want to add things to the dropdown lists, this can be done immediately by me.

A quick note on the „verifier" and „decision maker" specified in the form: in future this will be automatically filled in based on the specified lesson learned. However, for now it is a name that needs to be entered manually. As the pilot is only within the [group], you should only specify people within this group as verifier or decision maker for the pilot.

Thanks!

[Name of Knowledge Manager at MarineOrg]

Box D.12: Invitation to participate in survey prior to the pilot phase

Dear [name],

In the coming months [MarineOrg] pilots a new lessons learned (LL) system to improve the

[2]Electronic surveys were conducted with Limesurvey and used the templates provided in the system (see https://www.limesurvey.org, last access: 17 October 2016).

gathering of LL. The [department/group] is participating in this pilot. The pilot phase is accompanied by two surveys comparing the current situation of lessons learned with the new system.

You are therefore kindly requested to participate in the survey assessing the current situation by clicking on the link below. Please fill out the survey until 1st May latest. The survey should take about 15 min of your time. Please note that for timekeeping purposes you can use [code]. The survey application automatically keeps track on who participated in the survey. To avoid confusion please don't share your link to the survey with your colleagues.

If you have any questions, e.g., on the contents of the questionnaire, please don't hesitate to contact me.

Thanks in advance,

Tanja Buttler

————————————————- Click here to do the survey: [survey_url]

If you do not want to participate in this survey and don't want to receive any more invitations please click the following link: [opt_out_url]

Box D.13: Reminder to participate in the PRE-survey

Dear [name],

Recently we invited you to participate in a survey assessing the current situation on lessons learned at [MarineOrg].

We note that you have not yet completed the survey, and wish to remind you that the survey is still available.

You might not have had an opportunity to work with the lessons learned systems at [MarineOrg] yet. Even though, it would be quite valuable for us if you respond, because there are some questions in the survey asking about actual use as well. The survey questions contain the option *don't know*. Please feel free to use this option any time you are not sure what to answer, or where you think the question is not applicable to you. If you decide not to participate, please click on the link at the end of this email.

Kind Regards,

Tanja Buttler

Click here to do the survey: [survey_url]

If you do not want to participate in this survey and don't want to receive any more invitations please click the following link: [opt_out_url]

Box D.14: Introduction to the survey in MarineOrg prior to the pilot phase

In the coming months MarineOrg pilots a new lessons learned (LL) system to improve the gathering of LL. The results of this questionnaire will be used anonymously for the evaluation of this LL system.

The research is conducted by the Systems Engineering department of TPM at Delft University of Technology. This questionnaire contains a reference number that allows us to compare the answers you give here with answers obtained in a later stage in the pilot phase. TU Delft is committed to your anonymity and guarantees that MarineOrg will only gain access to an anonymized version of any results.

Please note that this questionnaire refers to the situation of lessons learned *before* the start of the pilot phase. At this stage we ask you to assess the "old" situation where only applications such as Excel were used to collect lessons learned. Think about how lessons learned were handled 3 month ago.

Table D.1: Demographical survey questions (MarineOrg)

Items
Age
Gender (man, woman, no answer)
Current Position

D.1.4.2 ... after the pilot phase in MarineOrg

Box D.15: Announcing the post-survey to DepartmentCol I & II and RepositoryCol

Dear all,

A few months ago you filled in a questionnaire from Tanja Buttler(TU Delft) on the current situation with regards to lessons learned. Since then you have had the opportunity to use the new system. Next week Tanja will send out a new questionnaire to asses this „new" situation. If you have not yet used the new system, please do so before filling in the questionnaire to ensure we have valid results.

Your cooperation is highly appreciated,

Regards,

[Name of Knowledge Manager at MarineOrg]

Box D.16: Invitation to participate in the survey after the pilot phase

Dear [name]

In the last months you have participated in a pilot for a new lessons learned (LL) system at [MarineOrg]. This LL system is evaluated through a questionnaire.

You are therefore kindly requested to participate in the questionnaire assessing the piloted system by clicking on the link below. Please fill out the survey until 31st August latest. The survey should take about 15 min of your time. Please note that for timekeeping purposes you can use [code]. The survey application automatically keeps track on who participated in the survey. To avoid confusion please don't share your link to the survey with your colleagues.

If you have any questions, e.g., on the contents of the questionnaire, please don't hesitate to contact me.

Thanks in advance,

Tanja Buttler

Click here to do the survey: [survey_url]

If you do not want to participate in this survey and don't want to receive any more invitations please click the following link: [opt_out_url]

Box D.17: First reminder to participate in the Post-survey

Dear [name],

Recently we invited you to participate in a survey assessing the piloted lessons learned system at [MarineOrg].

We note that you have not yet completed the survey, and wish to remind you that the survey is still available.

If you decide not to participate, please click on the link at the end of this email.

Kind Regards,

Tanja Buttler

Click here to do the survey: [survey_url]
If you do not want to participate in this survey and don't want to receive any more invitations please click the following link: [opt_out_url]

Box D.18: Second reminder to participate in the Post-survey

Dear All,
I would hereby like to kindly remind you to complete the Lessons Learned survey of Tanja Buttler. Please use the link as shown in the original invitation sent by Tanja, or the link in the reminder you received last week from Tanja. Please do so as soon before Tuesday the 18th, as we need the results to be able to have the MT decide on implementation of this lessons learned set-up.
Thanks,
[Name of Knowledge Manager at MarineOrg]

Box D.19: Introduction to the survey in MarineOrg after the pilot phase

In the last months MarineOrg has piloted a new lessons learned (LL) system to improve the gathering of LL. The results of this questionnaire will be used anonymously for the evaluation of this LL system. Please be aware that not all aspects evaluated in the questionnaire have been covered in the pilot phase.

The research is conducted by the Systems Engineering department of TPM at Delft University of Technology. This questionnaire contains a reference number that allows us to compare the answers you give here with answers obtained in the previous questionnaire. TU Delft is committed to your anonymity and guarantees that MarineOrg will only gain access to an anonymized version of any results we obtain through this questionnaire.

Please note that this questionnaire refers only to the lessons learned activities *during* the pilot phase.

Table D.2: Evaluation of the outcomes of the LLCP

Construct	Question
Content quality of LL	*The LL in the piloted system . . .*
	Words and phrases describing the content of a LL are used consistently.
	The format for a LL is logical and fitting .
	. . . are available at a time suitable for their use.
	. . . are important for my work.
	. . . are helpful for my work.
	. . . are meaningful and understandable.
	. . . are practicable.
	The categorization of a LL is clear and unambiguous.
Quality of LL – single items	The LL in the piloted system are practicable.
	The LL provide sufficient context so that I can easily understand it and apply it to my work
	The piloted LL system provides a complete knowledge portal so that I can link to knowledge or information sources for more detailed inquiries

The items on knowledge and information quality of lessons learned were based on a construct developed by (Wu and Wang, 2006).

Box D.20: Open questions (MarineOrg)

- Do you have any comments on how we can improve the LL processes?
- Do you have any suggestions on how we can improve the piloted LL system?

D.2 Data Collection in the InnovProject

D.2.1 Interview Guides InnovProject

For the InnovProject, there were two interviews. The first one was an open ended interview with the purpose to explore the process[3], and to discuss access to documents.

The second interview was semi-structured, and had the purpose to clarify issues that arose from the collected data, and to collect missing information (see Box D.21 for the specific questions). Box D.4 on page 266 (plus the question on which supporting role did what) was used as a guiding framework to check for missing information.

Box D.21: Interview guide for the second interview in the InnovProject

Missing information:

- How were the participants informed?
- How was the communication during the session handled?
  - What were the options for the setting?
- What was the goal of the process?
- How many participants? Did they have experience with the process in GSS?
- Did participants check back in /contribute asynchronously? How do you know?
- What were the anonymity settings?
- Who did the merging? (and other stuff between sessions)
- Who created the official LL report?

Clarification & Confirmation:

- How did you handle the voting results (some discrepancies between rank of a LL and which LL made it into the last round)?
- What does the section 'for administration' in the exports mean?
- Did you put any particular emphasis on collecting positive LL?
- What were the three ThinkLets used? (my assumption: LeafHopper, MultiCriteria Voting, LeafHopper)

[3] As the facilitator had extensive experience with collaboration engineering this process description was quite detailed.

D.2.2 Survey[4]

Box D.22: Introduction to the survey in InnovOrg

You have recently participated in a lessons learned session. This anonymous questionnaire evaluates these sessions. The evaluation is conducted by the Systems Engineering department of TPM at Delft University of Technology. The results of this questionnaire will be used for the [InnovProject] and for research of TPM.

Table D.3: Demographical survey questions (InnovProject)

Item
Age
Gender (man, woman, no answer)
Current Position
What is your nationality?

Table D.4: Evaluation of the outcomes of the LLCP

Constructs and Items	Question
Content quality of LL – reduced scale	*The lessons learned (LL) collected in the session ...*
	Words and phrases describing the content of a LL are used consistently.
	... are important for my work.
	... are helpful for my work.
	... are meaningful and understandable.
	... are practicable.
	The categorization of a LL is clear and unambiguous.
Quality of LL – single items	The recommendations developed in the session are practicable
	The LL provide sufficient context so that I can easily understand it and apply it to my work
Commitment	*I support ...*
	... the recommendations given in the session.
	... the way the challenges were described in the session.
	I feel committed to the lessons learned.
Satisfaction with results – reduced scale	
	I am satisfied with the things that we achieved in the session.
	I am happy with the results of the workshop.
	Our accomplishments give me a feeling of satisfaction.
	Overall, I am satisfied with the results of the session.

The items on knowledge and information quality of lessons learned were based on a construct developed by Wu and Wang (2006). The items on the satisfaction with the results were based on Briggs et al. (2003).

[4]Electronic surveys were conducted with Limesurvey and used the templates provided in the system (see https://www.limesurvey.org, last access: 17 October 2016).

Box D.23: Open questions (InnovProject)

- How can we improve the lessons learned session?
- Do you have any other remarks you wish to share?

D.3 Data Collection in the RefineryProject

D.3.1 Instrument C3: Interview Guide for assessing the Quality of Process and Outcome in the RefineryProject

To obtain an independent assessment of the outcome (here: the lessons learned report) and process quality, the program manager was interviewed.

Box D.24 (plus the question on which supporting role did what) was used as an interview guide. The interview guide allows the interviewee to develop his/her own quality criteria, that can be discussed for several lessons learned. During the interview, the lessons learned report of the RefineryProject served as a prompt.

Box D.24: Instrument C3: Interview guide for the outcome assessment in the RefineryProject

Outcome quality

Considering the whole lessons learned report:

- Were the LL useful, and did you do something with the LL?
  - Was there an opportunity to use some of the LL in usage context discussed before LLCP (here: in another part of the program)?
- When you look at this report, are there any important topics that we were really missed on? Other major gaps?
- What do you think of the overall quality of the report?
- What did you do with the report?

Eliciting quality criteria and discussing the quality of lessons learned (selected by the interviewee):

- Is there a good lessons learned in the report? Why is it a good one?
- And is there a lessons learned that is bad? Why is it a bad one?
- For discussing emerging main quality criteria:
  - Is criteria an important quality criteria? Why?
  - What are other criteria? /What are [other] issues with the lessons learned that emerge when reusing LL?
- What about ? (repeat question!)

Process quality

- Is there any feedback on the quality of the process that we used, apart from [already discussed factors]?

D.3.2 Survey

Box D.25: Introduction to the survey in the RefineryProject

Enquête Kwaliteit - Lessons Learned

[RefineryProject], Interviewer: A. Verbraeck, Facilitator: G. Kolfschoten

De resultaten van deze enquête worden volledig geanonimiseerd zonder context gebruikt voor onderzoek van de afdeling systeemkunde, faculteit techniek bestuur en management, technische universiteit delft.

Probeer alstublieft ieder antwoord apart te beoordelen.

Box D.26: Translation of introduction to the survey in the RefineryProject

Questionnaire quality of lessons learned approach

[RefineryProject], Interviewer: A. Verbraeck, Facilitator: G. Kolfschoten

The results of this questionnaire will be used anonymously and without context information for research of the Systems Engineering department of the Faculty of Technology Policy and Management at Delft University of Technology.

Table D.5: Demographical survey questions (RefineryProject)

Dutch Original	English Translation
Wat is je leeftijd?	Age
Wat is je sex (Man, Vrouw)	Gender (man, woman, no answer)
Hoeveel jaren werkervaring heb je?	How many years of working experience do you have?
Wat is je land van herkomst?	What is your country of origin?

Table D.6: Outcome related survey questions (RefineryProject)

Constructs and Items	Dutch Original	English Translation
Satisfaction with results	Ik ben blij met wat we bereikt hebben.	I feel happy with what we achieved today.
	Ik voel mij tevreden over de dingen die we bereikt hebben in het interview en in de workshop.	I feel satisfied with the things we achieved in today's workshop.
	Ik ben blij met de resultaten van het interview en de workshop.	I am happy with the results of today's workshop.
	Hetgeen we bereikt hebben geeft mij een gevoel van tevredenheid.	Our accomplishments today give me a feeling of satisfaction.
	Toen de workshop en het interview afgelopen was, voelde ik mij tevreden over de resultaten.	When the workshop was over, I felt satisfied with the results.
Commitment towards LL	Ik onderschrijf de bereikte uitkomsten.	I endorse the achieved outcomes.
	Ik ondersteun de uitkomsten van het interview en de workshop.	I support the outcomes of the interview and workshop.
	Ik ondersteun het bereikte resultaat.	I support the achieved results.
	Ik onderschrijf de resultaten.	I endorse the results.
	Ik committeer me aan de behaalde resultaten.	I feel committed to the achieved results.

The items on satisfaction were based on Briggs et al. (2003).

Box D.27: Open questions (RefineryProject)

- Wat vond je van het lessons learned proces dat werd gevolgt? (What did you think about the LLCP that was used?)
- Wat vond je van het interview? (What did you think about the interview?)
- Wat vond je van het resultaat? (What did you think about the interview?)
- Opmerkingen (Comments)

D.4 Instrument A1: Categorizing the Data

This instrument aims to prepare for further data analysis by creating a rough categorization of data relating to the aspects of the basic and extended model, and to separate statements relating to the quality of the process or the collected lessons learned. Table D.7 on the following page derives and explains the codes used in this instrument. The codes may be applied simultaneously (see Saldana (2009) for the technique). If the material was well structured (e.g., the report in TerminationCol already outlined the activity flow and associated tools with activities) this categorization of data was not or only partially used. For example, if a slide in the supporting material refers to the objective of a facilitated workshop, the slide would be coded as *Introduction*, and the objective would be coded as *Purpose*.

The main difficulty with this instrument was to demarcate activities. For data relating to software artifacts, the indicators presented in Box D.28 were used to tentatively demarcate the borders of an activity.

Box D.28: Instrument A1 / part 1 – Indicators for demarcating activities in software artifacts

- Buttons for submitting content
- Manipulable graphical objects (such as menus, links, tabs) for moving to another web-page indicate an activity if the new web-page presents more than just feedback (e.g., on whether the system has executed a user command successfully) to the user
- Manipulable graphical objects within a form are not used as indicators

Box D.29 was used to identify activities in other data types.

Box D.29: Instrument A1 / part 2 – Indicators for demarcating activities in interviews and documents

- agenda points
- (for documents) structure of the description of the process (e.g., items in an enumeration describing the overall process in InnovProject, or section headers in part of a report (TerminationProject)
- textual descriptions of sequences of activities (what are the steps?)
- changes in techniques and interaction settings (techniques were often identified based on literature)

Table D.7: Analysis Instrument A1: The instrument is used to apply structural and simultaneous codes during the first cycle of coding.

Code	Operationalization
... based on basic model	
Environment	basic information about the project or department, any influences (particularly from previous workshops) on how the collection process was designed, information on how the collection process influences or is expected to influence it's environment (particularly future projects), other *information on participants is not addressed here*
Instruments	general information about instruments that are not tools, and that are not clearly connected to an activity
(potential) Participants	general information about potential and actual participants; participant behaviour that covers more than one activity
Purpose	covers the immediate goal of the collection process, as well as any objective relating to influences on the environment (including long-term influences on participants)
... based on extended model	
Activity	statement or material relating to a *single* actual or abstracted activity involving participants; for facilitated processes, this code only includes activities of the main phase excluding the introduction
Introduction	facilitated processes only: opening phase of the main phase (includes any introduction given by the facilitator or the session owner)
Supporting Activity	a single supporting activity
Preparation Activity	statements indicating that a preparation activity took place
Postprocessing Activity	statement relating to post-processing activities
Interaction Setting	statements relating to interaction settings outside the code of an activity in which it is applied example: anonymity announced in the opening phase as part of the interaction setting during the main phase
Tools	general information about tools not clearly connected to a single activity
In situ adaptations	indications that the LLCP was adapted to the situation at hand
QA / QC	statements on the quality of the collected lessons learned, quality assurance, or quality issues with the process

- the main speaker changes (e.g., from facilitator to presenter)
- activities may be separated by breaks

D.5 Instrument A2: Flow of Activities

If necessary, the flow of activities was analyzed based on the initial categorization of activities. First, a flow chart of activities representing the time-line of a case was constructed. After creating an initial time-line for each case, the activities were further partitioned to ensure that sequences of activities with a similar input and output could be compared across cases.

Second, a time-ordered matrix was created (see Figure D.1 on the next page) in order to describe the activities and the process they form. Participant behavior, intermediary and final outputs, as well as other types of behavior were analyzed in the context of these activities. The matrix used individual activities or phases as time steps, and the variables describing an activity as rows.

	Phases:	Opening / Introduction	
Activity	Short Summary		
General Attributes	Initial Label [inferred?]		
	Internal Reference Number		
	Purpose [inferred, if not stated otherwise]		
	Duration / Available Time		
Input (tangible)	[inferred, if not stated otherwise]		
Output (intangible or tangible)	Expected output (may be based on purpose of activity or agenda point)		
	Reference to intermediary results and their analysis		
Roles (who does what)			
Interaction Setting	Reference to setting		
Instruments	Tools		
	Techniques		
	Configuration		
	Quality Control Aspects: deficiency prevention		
	Quality Control Aspects: deficiency discovery and fixing		
Participant Behaviour	What?		
Other			
My thoughts	Potential influence on other activities?		
	Other		

** Only list data that is explicitly mentioned. For inferring other activities use the appropriate instrument.*

Figure D.1: Analysis instrument A2: Temporal order matrix. The activities form the columns of the matrix, and should be entered in the order in which they are performed in the LLCP.

D.6 Abstraction Levels

As part of a summary, the abstraction level needs to be selected (Mayring, 2003, p.59ff). In general, there are several abstraction levels that were encountered in this research. For example a technique may be abstracted to

1. a variety of diverse process types (including, e.g., LLCPes, interviews for research purposes, and risk management processes)
2. several LLCPes
3. a particular LLCP

All three levels of abstraction may be relevant for the observed LLCPes. The last level may contain references to participants, the project, or specific problems of that project. The first level of abstraction can be found in textbooks describing specific techniques (see, e.g., Briggs and de Vreede (2009); Justice and Jamieson (2006)), while the first two levels of abstraction may be used to describe an abstract activity in a LLCP. Both the first and second level of abstraction have been used to describe the design of LLCPes in literature (see Baaz et al. (2010) for an example of such a description).

As it is the aim of this thesis to explore LLCPes, the last two levels of abstraction are particularly relevant: the second level allows a description of a LLCP that contains sufficient information to be transferred to other opportunities for collecting lessons learned, and the last level allows for a summary of idiosyncrasies of a LLCP.

Nevertheless, instruments such as techniques may be described on (and applicable to) the first level of abstraction, and can therefore be described on this levels as well.

Appendix E

Sources and Results per Case

E.1 Overview of Collected Qualitative Data

The following sections provide an overview of the collected qualitative data for each abstracted LLCP. The tables provide a case-specific overview of the first part of Figure 6.1 on page 78.

E.1.1 Qualitative Data (DeepwaterCol)

Table E.1: Data used in DeepwaterCol

Data source	Dates	Data	Data collection instrument
Document	27 Sep 11	Notes from meeting with knowledge manager	
Document	20 Dec 11	Notes taken during a meeting with knowledge manager: first mentioning of facilitated process	
Document	19 Mar 12	Email correspondence with knowledge manager about planned observations	
People	21 Mar 12	Observational notes taken during DeepwaterCol I	Section D.1.1 on page 265
People	21 Mar 12	Observational notes taken during DeepwaterCol II	Section D.1.1 on page 265
People	21 Mar 12	Observational notes added after the sessions	Section D.1.1 on page 265
People	21 Nov 12	Interview with knowledge manager for evaluating lessons learned efforts in MarineOrg (audio recordings, transcript, and notes)	Section D.1.3 on page 267
Document		Spreadsheet with collected lessons learned	

E.1.2 Qualitative Data (RepositoryCol)

Table E.2: Data used in RepositoryCol (excluding the survey)

Data source	Dates	Data	Data collection instrument
Document	27 Sep 11	Notes from meeting with knowledge manager	
Document	24 Feb 12	User guide for the application (early draft)	
Document	16 to 20 Mar 12	Email correspondence with knowledge manager	
Software artifact	16 Apr 12	Screenshot of the template for verifying a LL (accessed while documenting a LL)	
Software artifact	16 Apr 12	Screenshot of the template for authoring a LL	
Software artifact	17 Apr 12	Screenshot of the template for making decisions on suggested actions (accessed while documenting a LL)	
People	18 Apr 12	Transcript of interview with participant conducted prior to the LL pilot	Section D.1.2 on page 267
People	18 Apr 12	Transcript of interview with department head conducted prior to LL pilot	Section D.1.2 on page 267
Document	Jun 2012	Improvement log for the lessons learned application	
Document	4 Jun 12	User guide for the application (later draft)	
People	21 Nov 12	Interview with knowledge manager for evaluating lessons learned efforts in MarineOrg (audio recordings, transcript, and notes)	Section D.1.3 on page 267
		Spreadsheet with collected lessons learned	

E.1.3 Qualitative Data (DepartmentCol)

Table E.3: Data used in DepartmentCol (excluding the survey)

Data source	Dates	Data	Data collection instrument
Document	27 Sep 11	Notes from meeting with knowledge manager	
Document	24 Feb 12	User guide for the application (early draft)	
Document	16 to 20 Mar 12	Email correspondence with knowledge manager	
Document	20 Dec 11	Notes from meeting with knowledge manager	
People	18 Apr 12	Interview with participant conducted prior to the LLCP (notes and audio recording)	Section D.1.2 on page 267
People	18 Apr 12	Interview with participant conducted prior to the LLCP (notes and audio recording)	Section D.1.2 on page 267
People	18 Apr 12	Interview with participant conducted prior to the LLCP (notes and audio recording)	Section D.1.2 on page 267
People	25 May 12	Oral utterances in DepartmentCol I (partial transcript, notes, audio recording)	
People	25 May 12	Observational notes of DepartmentCol I	Section D.1.1 on page 265
People	29 May 12	Observational notes of DepartmentCol II	Section D.1.1 on page 265
People	29 May 12	Oral utterances in DepartmentCol II (partial transcript, notes, audio recording)	
Document	Jun-12	Improvement log for the lessons learned application	
People	21 Nov 12	Interview with knowledge manager for evaluating lessons learned efforts in MarineOrg (audio recordings, transcript, and notes)	Section D.1.3 on page 267
Document		Spreadsheet with collected lessons learned	

E.1.4 Qualitative Data (InnovCol)

Table E.4: Data used in InnovCol (excluding the survey)

Data source	Dates	Data	Data collection instrument
Document	nd	Preliminary agenda of InnovCol	
Document	9 May 12	Slides of InnovCol	
Document	9 May 12	Workshop results (Word and Excel format)	
Document	June 2012	Public report of lessons learned collected in the InnovProject (through several LLCPes)	
People	21 Jun 12	First interview with facilitator (notes, audio recording, and partial transcript)	Section D.2.1 on page 273
People	8 Aug 12	Second interview with facilitator (notes only)	Section D.2.1 on page 273

E.1.5 Qualitative Data (RefineryCol)

Table E.5: Data used in RefineryCol (excluding the survey)

Data source	Dates	Data	Data collection instrument
Document	nd	Interview guide and accompanying materials for interviewing phase	
Document	1st quarter 11	A1 to A7: Interviews (and partial transcripts) from the interviewing phase	
Document	nd	Intermediary lessons learned (in the form of a report)	
Document	nd	Slides used during the workshop	
Document	21 Jun 11	Oral utterances during the workshop phase (partial transcript and audio recording)	
Document	21 Jun 11	GSS export of contributions (both Word and Excel format)	
Document	Jun 11	Feedback from participants on report (via email)	
Document	11 Aug 11	Report of LLCP	
People	26 Apr 12	Evaluative interview (partial transcript and audio recordings) with knowledge manager	Section D.3.1 on page 275

E.1.6 Qualitative Data (TerminationCol)

Table E.6: Data used in TerminationCol

Data source	Dates	Data	Data collection instrument
Document	3 Jul 05	Spreadsheet with LL from the Termination-Project. LL were collected in the 2011 campaign, the last entry was on 20-Sept-11	
Document	21 Sept 11	Summary of several design problems and advice given in the preparation phase	
Document	27 Sept 11	Notes from meeting with knowledge manager	
Document	27 Oct 11	Draft of report on TerminationCol	
Document	Oct 11	Spreadsheet with results of TerminationCol (less extensive than draft report)	
Document	20 Dec 11	Meeting notes (meeting with knowledge manager regarding the piloted lessons learned efforts)	
People	21 Nov 12	Interview with knowledge manager for evaluating lessons learned efforts in MarineOrg (audio recordings, transcript, and notes)	Section D.1.3 on page 267

E.2 MarineOrg - General

E.2.1 Timeline of LLCP in MarineOrg

Table E.7: Occurrence of LLCPes in MarineOrg in ascending order in 2011 and 2012

Date	
11/10	TerminationCol (facilitated session)
21/02	DeepwaterCol I & II (facilitated sessions)
12/04	Announcement questionnaire & pilot activity
13/04 to 11/05	Survey for pre-measurements
16/04	Opening of LL application for RepositoryCol
25/05	DepartmentCol I (FO-Session)
29/05	DepartmentCol II (MM-Session)
10/08	Exporting all LL (in LL application)
14/08	Reminding participants of RepositoryCol to contribute their LL
24/08 to 21/09	Survey for post-measurements

E.3 TerminationCol

Table E.8: Extend of reduction through selecting lessons learned in TCD10

	After TCD9				After TCD10			
Theme	Title	Impact	Root cause	Action	Title	Impact	Root cause	Action
Safety	34	39	46	115	15	9	28	39
Engineering	49	53	53	167	19	17	26	66
Team	31	47	25	71	15	26	27	83
Communication	7	15	33	107	10	13	21	22
Project execution	8	10	20	129	6	2	16	91
	129	**164**	**177**	**589**	**65**	**67**	**118**	**301**

E.4 RepositoryCol

E.4.1 Criteria for Verification and Decision on Action

Box E.1: Verification criteria (RepositoryCol)

Verification of content

Significance of lesson: uniqueness

Validity: correct & objective content

Action-ability: sufficient context &detail to facilitate action

Comprehensibility for audience: now & future, current & other project teams

Box E.2: Criteria for making decisions on actions (RepositoryCol)

Verification of action: Should action be executed?

Validity of action: correctness & actionability

Necessity of action: likelihood of root cause reoccurring & impact of reoccurrence

Viability of action: balance between cost & benefit of executing action

E.4.2 Changes to Instruments in RepositoryCol

After the pilot phase, MarineOrg decided to change the template, based on feedback from about 20 core users. The following list covers changes to the template, as well as changes to the guidance of users.

- The *labels* used in the template and guideline were adapted to what the employees found suitable or easier to understand. For example, ‘root cause’ had been replaced with ‘possible causes’, because MarineOrg used a specific, quite elaborate, technique for analyzing root causes of incidents, which sometimes led to the expectation that lessons learned should use the same technique.

- All major sections of the template were extended with *instructions* telling an author what to do. The guiding questions in the actual lesson learned (see Table 8.2 on page 117) were extended, so that every field was accompanied by a question.

- MarineOrg planned to add *examples for high-quality lessons* learned to the home page.

- MarineOrg also planned to introduce *training* explaining the system, and answering the questions„what is a quality LL, or what is not a good LL, or what do we expect from you, what can you expect from others?"

- The *categorization* of lessons learned was reduced to three dimensions (e.g., the project, department & their sub-categories). Additional categories previously covered in the template could still be addressed through keywords. These free keywords were modified to be part of a *folksonomy*.

- The *assessment of the importance* of a LL for *future* projects was removed from the template.

- The assessment of the impact of a lesson learned on the *originating* project was extended to include closed questions on the impact regarding the project management dimensions of success used by MarineOrg.

- In order to improve the specificity of the *title* of a lesson learned, the order of the prompts in the template was changed, so that the template first asked about the project, and then the title. These changes were implemented with the intention to influence how users think through a lesson learned.

- Each action needs to have its own decision maker.

- One action can cover multiple lessons learned.

E.4.3 Perceived Quality of Lessons Learned in the Lessons Learned Application

Table E.9: Perceived quality of LL in the lessons learned application

	N	Median	Q1	Q3
Content quality of LL (8 items)	4	5.8	4.8	5.6
Content quality of LL (reduced scale, 6 items)	5	5.5	5	5.9
Items				
The LL in the piloted system are practicable.	6	5	4	5.3
The LL provide sufficient context so that I can easily understand it and apply it to my work	8	6	4.3	6
The piloted LL system provides a complete knowledge portal so that I can link to knowledge or information sources for more detailed inquiries	7	6	4	6

E.5 RefineryCol

E.5.1 Interview Guide

Box E.3: Interview guide for the interviewing phase in RepositoryCol

1. Explain what we try to accomplish
   (a) LL through first individual storytelling
   (b) then bring information together
   (c) usage of tagged and hyperlinked documents & story snippets for distributing lessons learned
   (d) ensure that taped interview will be used by us only
   (e) but indicate later we might want to use info more widely (give example)
2. Ask participants about project role and context
   (a) time in project (from .. to ..)
   (b) role and responsibilities in project
   (c) definition of success for the project and whether this was achieved
3. Ask participants to present list of topics for lessons learned
   (a) use ‘topics to cover’ to help them if needed
   (b) identify quickly based on [. . .] scoresheet if this is a true LL
4. Cover topics they mentioned one-by-one
   (a) Use [. . .] template to get as many dimensions to the LL as possible
   (b) have them talk as much as possible, but keep timeline and get the items for the dimensions
5. Explain next steps
   (a) other people we might have to interview as well in their opinion?
   (b) process results
   (c) joint session
   (d) report and wiki

Additional materials for the interviews included a scoresheet for assessing whether a contribution was actually a lesson learned, a list of prepared topics to support participants in identifying potential topics for lessons learned, and a template outlining the structure of lessons learned.

E.5.1.1 Inquiring about lesson learned (interviewing phase)

This template of a lesson learned was used to guide questions about a lesson learned. The template was based on questions found in ongoing research at the university. There was no requirement to cover all questions.

Box E.4: Template for lessons learned

Description of context Situation in which lesson was learned; What was supposed to happen & what actually happened?

Root cause/Challenges Why was the outcome different than expected; be specific

Lessons Learned - Recommendation for future In this field state the lesson and the insights; it should be specific and actionable and a recommendation

Action - Implementation of Lesson What action needs to be taken, to ensure that the lesson learned is implemented into this/other/future projects

Importance of Action Why is it important that this action is taken?

Danger Spots Specify possible drawbacks and issues around the lesson

Date action required

Accountable person for action Who is responsible for the action being completed

Additional Visualization In this field you can insert hyperlinks to for instance incident reports, pictures, videos, diagrams, drawings, cause-effect diagrams, causal diagrams, flow diagrams, statistics etc

Interfaces If applicable, specify the procedure/working method/standard/other lesson too which the lesson/action is related

Other Comments/ Attachments

Project stage

Department Department for who the lesson/action is relevant

Functional Discipline To which functional discipline does the lesson/action apply

Category To which of the TECOP-areas does the lesson apply?

Relevant process Process in which lesson was learned; related to WBS

Originator

E.5.2 Templates for Positive and Negative Lessons Learned

Boxes E.5 and E.6 show the lessons learned templates suggested in RefineryCol. Both templates were first published in Buttler and Lukosch (2012). During the LLCP, they were used to identify the components of lessons learned.

Box E.5: Template for negative lessons learned

Title short title referring to the effect or incident

Problem Description a short description of the problem

Symptoms a list of symptoms that characterizes the problem

Expectations and Actual Events : should answer the questions "What was done?", "What was the expected result?", "What were the actual events/ consequences?"

Metadata contextualize the lessons learned

List of Contributing Factors : lists all (relevant) factors that contribute to the gap. Each factor results in a single lesson learned described through the following items:

- **Title** short title referring to the contributing factor
- **Description (Rationale)** how does the factor contribute to the gap.
- **Recommendation** what should be done to reduce the influence of this factor (or eliminate its influence)?

Box E.6: Template for positive lessons learned

Title

Problem Description/ Opportunity for Improvement why and in which situations the solution should be implemented

Symptoms a list of symptoms that characterizes the problem

Solution (and Rationale) provides a high level description of the solution, and how it contributes to solving the problem

How to Do It provides details regarding the implementation of the solution

Danger Spots describes danger spots, where the implementation can easily go wrong, and the disadvantages of the solutions, links to other lessens learned that might address the danger spots

Metadata contextualize the lessons learned

E.5.3 Process Evaluation

During the LLCP, participants evaluated the activities. Also, the researcher made some observations regarding the efficiency and effectiveness of the GSS. This sections displays key results from these discussions for reasons of completeness.

RPWD1 (observations)

The brainstorming tool did not seem to direct attention as needed (e.g., exclamation marks would help the facilitator to direct the attention of participants towards specific items; other indicators could be used to show when a lesson learned has new comments).

RPWD3 Reflection by participants during the activity:

- options are too broad
- framework was used in OwnerOrg to categorize/identify/structure sources of risk by selecting one key thing; in this activity it was used for comprehensive categorization
  - participants considered it more meaningful to use the predefined framework plus free tags
- suggested improvement: define typical things that go wrong in a project, and use one category for that

RPWC1

- suggestions re quality of the LLCP
  - analysis phase: things are not correctly transcribed or interpreted – ask for (written feedback after the interview)
  - participants have a different view on whether something is a LL or not/is it really the majority of the team that thought this was a LL?
  - workshop did not include any challenging of the results in the form of a discussion, which was perceived as leading to clearer conclusions
  - identify wrong statements [leads participants to reflect on events in the project, and how misunderstanding could have arisen)
- remarks on very tight schedule: the participants could have spent a day on these discussions

- GSS - wonderful, because everyone can contribute; first-time use – there is room for improvement
  - rating and contributing perceived positives; categorization should not have been in this one
  - potential to contribute a lot of data during this exercise
- approach is good - modified process
  - interview to gather data
  - put subjects on the table where there was a lot of disagreement in the team and straighten that out in an open discussion
  - do the scoring (already agreement on content!)

E.6 InnovProject

Table E.10: Number of guiding questions asked regarding the *selected* LL during the initial gathering and the elaboration activity (InnovProject)

Sub-Theme	# Questions in IPD1	# Question in IPD3
Interfaces	1	0
Technical Theme 1	13	2
Technical Theme 2	2	2
Technical Theme 3	3	2
Other	1	0
	20	**6**

Table E.11: Number of LL per sub-theme before and after the application of the voting results in IPS2

Sub-Theme	# LL after IPD1	# LL after IPS2	# LL with additional comments after IPD3
Interfaces	5	2	2
Technical Theme 1	16	5	5
Technical Theme 2	5	3	2
Technical Theme 3	16	2	2
Other	10	2	0
	52	**14**	**11**

Table E.12: Extend of elaboration in IPD3 (limited to the lessons learned selected in IPS2)

Theme	# Selected LL	Sum of Comments	Sum of Added Comments	Sum of Words	Sum of Added Words
Interfaces	2	9	5	302	81
Technical Theme 1	5	34	18	1253	821
Technical Theme 2	3	16	19	428	506
Technical Theme 3	2	7	30	152	883
Other	2	6	0	157	0
	14	**72**	**72**	**2292**	**2291**

Bibliography

Ajmal, M., Helo, P., and Kekäle, T. (2010). Critical factors for knowledge management in project business. *Journal of Knowledge Management*, 14(1):156–168.

Ajmal, M. M., Kekäle, T., and Takala, J. (2009). Cultural impacts on knowledge management and learning in project-based firms. *VINE*, 39(4):339–352.

Ajzen, I. and Fishbein, M. (2005). The influence of attitudes on behaviour. In Albarracín, D., Johnson, B. T., and Zanna, M. P., editors, *The Handbook of Attitudes*, pages 173–221. Erlbaum, Mahwah, NJ.

Aljafari, R. and de Vreede, G.-J. (2010). A review of anonymity in electronic collaboration. In de Vreede, G.-J., editor, *Proceedings of the 11th Group Decision and Negotiation Conference*, pages 144–148. The Center for Collaboration Science, Omaha, NE.

Alter, S. (2013). Work system theory: overview of core concepts, extensions, and challenges for the future. *Journal of the Association for Information Systems*, 14(2):72–121.

Ariely, D. and Carmon, Z. (2000). Gestalt characteristics of experiences : The defining features of summarized events. *Journal of Behavioral Decision Making*, 13:191–201.

Baaz, A., Holmberg, L., Nilsson, A., Olsson, H. H., and Sandberg, A. B. (2010). Appreciating lessons learned. *IEEE Software*, 27(4):72–79.

Bakker, R. M. (2010). Taking stock of temporary organizational forms: A systematic review and research agenda. *International Journal of Management Reviews*, 12(4):466–486.

Barney, C. (2011). Cross-project learning in project-based organizations. Master thesis, Delft University of Technology. Retrieved from http://repository.tudelft.nl. Last accessed on August 15, 2016.

Bentley, C. (2010). *Prince2 A practical handbook*. Butterworth-Heinemann, Oxford, United Kingdom.

Birk, A., Dingsøyr, T., and Stålhane, T. (2002). Postmortem: Never leave a project without it. *IEEE Software*, 19(3):43–45.

Bostrom, R. P. and Anson, R. (1992). The face-to-face meeting: A tutorial. In Bostrom, R. P., Watson, R. T., and Kinney, S. T., editors, *Computer Augmented Teamwork, A Guided Tour*, chapter 2, pages 16–33. Van Nostrand Reinhold, New York, NY.

Bougheas, S., Nieboer, J., and Sefton, M. (2013). Risk-taking in social settings: Group and peer effects. *Journal of Economic Behavior and Organization*, 92:273–283.

Briggs, R. O. and de Vreede, G.-J. (2009). *ThinkLets: Building blocks for concerted collaboration*. Lulu.com, Raleigh, NC.

Briggs, R. O., de Vreede, G.-J., and Reinig, B. A. (2003). A theory and measurement of meeting satisfaction. In *System Sciences, 2003. Proceedings of the 36th Annual Hawaii International Conference on*, Big Island, HI. ACM Press.

Briggs, R. O., Kolfschoten, G. L., de Vreede, G.-J., Albrecht, C., Lukosch, S. G., and Dean, D. L. (2014). A six-layer model of collaboration. In Mittleman, D. D., Murphy, J. D., and Briggs, R. O., editors, *Collaboration systems: Concept, value, and use*, volume 19 of *Advances in Management Information Systems*, chapter 13, pages 211–227. M.E.Sharpe, Armonk, NY.

Briggs, R. O., Reinig, B. A., and de Vreede, G.-J. (2012). The yield shift theory of satisfaction and its application to the IS/IT domain. In Dwivedi, Y. K., Wade, M. R., and Schneberger, S. L., editors, *Information systems theory: Explaining and predicting our digital society*, volume 29 of *Integrated Series in Information Systems*, chapter 11, pages 185–217. Springer Verlag, New York, NY.

Brown, S., Massey, A., Montoya-Weiss, M., and Burkman, J. (2002). Do I really have to? User acceptance of mandated technology. *European Journal of Information Systems*, 11(4):283–295.

Bryman, A. and Bell, E. (2007). *Business research methods*. Oxford University Press, Oxford, NY, 2nd edition.

Busby, J. S. (1999). The effectiveness of collective retrospection as a mechanism of organizational learning. *The Journal of Applied Behavioral Science*, 35(1):109–129.

Buttler, T. and Lukosch, S. G. (2012). Rethinking lessons learned capturing: Using storytelling, root cause analysis, and collaboration engineering to capture lessons learned about project management. In Lindstaedt, S. and Granitzer, M., editors, *Proceedings of the 12th International Conference on Knowledge Management and Knowledge Technologies - i-KNOW '12*, pages 1–8. ACM Press, New York, NY.

Buttler, T. and Lukosch, S. G. (2013). On the implications of lessons learned use for lessons learned content. In *i-know'13, Proceedings of the 13th International Conference on Knowledge Management and Knowledge Technologies*, Graz, Austria. ACM Press.

Buttler, T., Lukosch, S. G., and Verbraeck, A. (2011). Frozen stories: Capturing and utilizing frozen stories for teaching of project managers. In Verbraeck, A. and Helfert, M., editors, *Proceedings of the 3rd International Conference on Computer Supported Education*, pages 120–129. SciTePress, Setúbal, Portugal.

Cacciatori, E., Tamoschus, D., and Grabher, G. (2011). Knowledge transfer across projects: Codification in creative, high-tech and engineering industries. *Management Learning*, 43(3):309–331.

Cannon, M. D. and Edmondson, A. C. (2005). Failing to learn and learning to fail (intelligently): How great organizations put failure to work to innovate and improve. *Long Range Planning*, 38(3):299–319.

Carifio, J. and Perla, R. (2008). Resolving the 50-year debate around using and misusing Likert scales. *Medical Education*, 42(12):1150–2.

Carrillo, P. (2005). Lessons learned practices in the engineering, procurement and construction sector. *Engineering, Construction and Architectural Management*, 12(3):236–250.

Carrillo, P., Ruikar, K., and Fuller, P. (2013). When will we learn? Improving lessons learned practice in construction. *International Journal of Project Management*, 31(4):567–578.

Chaiken, S. and Maheswaran, D. (1994). Heuristic processing can bias systematic processing: effects of source credibility, argument ambiguity, and task importance on attitude judgment. *Journal of personality and social psychology*, 66(3):460–473.

Chalmers, A. F. (1999). *What is this thing called Science?* Open University Press, Berkshire, United Kingdom, 3rd edition.

Chaves, M. S. and Veronese, G. S. (2014). A proposal to manage lessons learned in projects management: web 2.0 technologies to promote innovation. *International Journal of Innovation*, 2(1):1–17.

Chi, M. T., Feltovich, P. J., and Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5(2):121–152.

Clawson, V. K. and Bostrom, R. P. (1993). The facilitation role in group support systems environments. In Tanniru, M. R., editor, *Proceedings of the 1993 Conference on Computer Personnel Research*, pages 323–335. ACM Press, New York, NY.

Cohen, L., Manion, L., and Morrison, K. (2011). *Research methods in education*. Routledge, New York, NY, 7th edition.

Collier, B., DeMarco, T., and Fearey, P. (1996). A defined process for project post mortem review. *IEEE Software*, 13(4):65–72.

Cook, W. D. and Seiford, L. M. (1978). Priority ranking and consensus formation. *Management Science*, 24(16):1721–1732.

Cooke-Davies, T. (2002). The real success factors on projects. *International Journal of Project Management*, 20(3):185–190.

Coolican, H. (2013). *Research methods and statistics in psychology*. Hodder Education, London, United Kingdom, 5th edition.

Cooper, K. G., Lyneis, J. M., and Bryant, B. J. (2002). Learning to learn, from past to future. *International Journal of Project Management*, 20(3):213–219.

"Credibility [Simple Def.]" (n.d.). Merriam-webster online. http://www.merriam-webster.com/dictionary/credibility. Last accessed on June 16, 2016.

Cross, R. and Sproull, L. (2004). More than an answer: Information relationships for actionable knowledge. *Organization Science*, 15(4):446–462.

Danermark, B., Ekström, M., Jakobsen, L., and Karlsson, J. C. (2002). *Explaining Society: An Introduction to Critical Realism in the Social Sciences*. Routledge, New York, NY.

DeLone, W. and McLean, E. (2003). The DeLone and McLean model of information systems success : A ten-year update. *Journal of Management Information Systems*, 19(4):9–30.

DeLone, W. H. and McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3(1):60–95.

Disterer, G. (2002). Management of project knowledge and experiences. *Journal of Knowledge Management*, 6(5):512–520.

Downey, R. G. and King, C. V. (1998). Missing data in Likert ratings: A comparison of replacement methods. *The Journal of General Psychology*, 125(2):175–191.

Duggan, G. B. and Payne, S. J. (2011). Skim reading by satisficing: Evidence from eye tracking. In *Proceedings of the SIGCHI Conference on Human Factors in Computing (CHI '11)*, pages 1141–1150, New York, NY. ACM Press, New York, NY.

Duivenvoorde, G. P. J., Kolfschoten, G. L., Briggs, R. O., and de Vreede, G.-J. (2009). Towards an instrument to measure successfulness of collaborative effort from a participant perspective. In *Proceedings of the 42nd Hawaii International Conference on System Sciences, 2009. HICSS '09*, pages 1–9.

Eagly, A. H. and Chaiken, S. (1993). Process theories of attitude formation and change: The elaboration likelihood and heuristic-systematic models. In *The Psychology of Attitudes*, chapter 7, pages 305–349. Harcourt Brace Jovanovich, Orlando, FL.

Easton, G. (2010). Critical realism in case study research. *Industrial Marketing Management*, 39(1):118–128.

Edmondson, A. C. (2002). The local and variegated nature of learning in organizations: A group-level perspective. *Organization Science*, 13(2):128–146.

Edmondson, A. C. (2003). Managing the risk of learning: Psychological safety in work teams. In West, M. A., Tjosvold, D., and Smith, K. G., editors, *International Handbook of Organizational Teamwork and Cooperative Working*, pages 255–275. John Wiley & Sons, Chichester, United Kingdom.

Esser, J. (1998). Alive and well after 25 Years: A review of groupthink research. *Organizational behavior and human decision processes*, 73(2–3):116–141.

Eysenck, M. A. and Keane, M. T. (2010). *Coginitive psychology: A student's handbook*. Psychology Press, New York, NY, 6th edition.

Fjermestad, J. and Hiltz, S. R. (1999). An assessment of group support systems experimental research : Methodology and results. *Journal of Management Information Systems*, 15(3):7–149.

Folker, E. (2011). Lesbarkeit von Schulbüchern: Wie die Lesbarkeit den Lernerfolg beeinflusst und wie man Lesbarkeitsformeln anwendet. *Wirtschaft und Erziehung*, 63(1-2):17–20.

Getzels, J. (1979). Problem finding: A theoretical note. *Cognitive Science*, 3:167–172.

Gibson, E. G. J., Caldas, C. H., Yohe, A. M., and Weerasooriya, R. (2007). An analysis of lessons learned programs in the construction industry (2nd ed.). Technical report, Construction Industry Institute, Austin, TX.

Girotto, V., Ferrante, D., Pighin, S., and Gonzalez, M. (2007). Postdecisional counterfactual thinking by actors and readers. *Psychological Science*, 18(6):510–5.

Girotto, V., Legrenzi, P., and Rizzo, A. (1991). Event controllability in counterfactual thinking. *Acta Psychologica*, 78(1-3):111–133.

Gliem, J. A. and Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. In *2003 Midwest Research to Practice Conference in Adult, Continuing, and Community Education*, pages 82–88, Columbus, OH.

Harder, R. J., Keeter, J. M., Woodcock, B. W., Ferguson, J. W., and Wills, F. W. (2005). Insights in implementing collaboration engineering. In *Proceedings of the 38th Hawaii International Conference on System Sciences*, page 15b. IEEE.

Hillson, D. (2002). Extending the risk process to manage opportunities. *International Journal of Project Management*, 20(3):235–240.

Hillson, D. (2003). *Effective opportunity management for projects: Exploiting positive risk*. PM Solutions Research. CRC Press, Boca Raton, FL.

Hillson, D. and Simon, P. (2007). *Practical project risk management: The ATOM methodology*. Management Concepts, Vienna, VA.

Hofstede, G., Hofstede, G. J., and Minkov, M. (2010). *Cultures and organizations: Software of the mind*. McGraw Hill, New York, NY, 3rd edition.

Hogg, M. A. and Vaughan, G. M. (2008). *Social psychology*. Pearson Education, Harlow, United Kingdom, 5th edition.

Hubbard, D. W. (2009). *The failure of risk management: Why it's broken and how to fix it*. John Wiley & Sons, Hoboken, NJ.

Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education*, 38(12):1217–8.

Justice, T. and Jamieson, D. W. (2006). *The facilitator's fieldbook: Step-by-step procedures, checklists and guidelines, samples and templates*. American Management Association, New York, NY, 2nd edition.

Kahneman, D. (2000). Evaluation by moments : Past and future. In Kahneman, D. and Tversky, A., editors, *Choices, Values and Frames*, chapter 38. Cambridge Univ. Press, New York, NY.

Kahneman, D. and Tversky, A. (1982). The simulation heuristic. In Kahneman, D., Slovic, P., and Tversky, A., editors, *Judgement under uncertainty: Heuristics and biases*, chapter 14, pages 201–208. Cambridge University Press, Cambridge, United Kingdom.

Kasi, V., Keil, M., Mathiassen, L., and Pedersen, K. (2008). The post mortem paradox: a Delphi study of IT specialist perceptions. *European Journal of Information Systems*, 17:62–78.

Keegan, A. and Turner, J. R. (2001). Quantity versus quality in project-based learning practices. *Management Learning*, 32(1):77–98.

Klein, G. (2008). Naturalistic decision making. *Human Factors*, 50(3):456–460.

Kolfschoten, G. L. (2007). *Theoretical foundations of collaboration engineering*. PhD thesis, Delft University of Technology, Delft, The Netherlands.

Kolfschoten, G. L., Grünbacher, P., and Briggs, R. O. (2011). Modifiers for quality assurance in group facilitation. *Group Decision and Negotiation*, 20(5):685–705.

Koners, U. (2005). *Learning from research & development projects: The role of post-project reviews*. Phd thesis, Cranfield School of Management, Bedford, United Kingdom.

Kotnour, T. (2000). Organizational learning practices in the project management environment. *International Journal of Quality & Reliability Management*, 17(4/5):393–406.

Kulkarni, U., Ravindran, S., and Freeze, R. (2007). A knowledge management success model: Theoretical development and empirical validation. *Journal of Management Information Systems*, 23(3):309–347.

Larkin, J., Simon, D. P., Simon, H. A., and McDermott, J. (1980). Expert and novice performance in solving physics problems. *Science*, 208(June):1335–1342.

Lee, D. H. and Schleyer, T. (2012). Social tagging is no substitute for controlled indexing : A comparison of medical subject headings and CiteULike tags assigned to 231,388 papers. *Journal of the American Society for Information Science and Technology*, 63(9):1747–1757.

Liebowitz, J. (2008). Two forgotten elements of a knowledge management strategy. *Knowledge Management Research & Practice*, 6(3):239–244.

Linke, A., Nussbaumer, M., and Portmann, P. R. (1991). *Studienbuch Linguistik*. Max Niemeyer Verlag, Tübingen, Germany.

Liu and Ziming (2005). Reading behavior in the digital environment: Changes in reading behavior over the past ten years. *Journal of Documentation*, 61(6):700–712.

Locke, E. a. and Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, 57(9):705–717.

Loftus, E. F. (2005). Planting misinformation in the human mind: a 30-year investigation of the malleability of memory. *Learning & memory*, 12(4):361–366.

Loos, E. E., Anderson, S., Day, D. H. J., Jordan, P. C. and Wingate, J. D. (Eds.) (2004). Glossary of linguistic terms. http://http://www-01.sil.org/linguistics/ GlossaryOfLinguisticTerms/. Last accessed on March 17, 2015.

Lussier, D. a. and Olshavsky, R. W. (1979). Task Complexity and Contingent Processing in Brand Choice. *Journal of Consumer Research*, 6(2):154.

Mayring, P. (2003). *Qualitative Inhaltsanalyse*. Beltz Verlag, Weinheim, Germany and Basel, Switzerland, 8th edition.

Mentzas, G., Apostolou, D., Abecker, A., and Young, R. (2003). *Knowledge asset management: Beyond the process-centred and product-centred approaches*. Springer Verlag, London, United Kingdom.

Miles, M. B. and Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage Publications, Thousand Oaks, CA, 2nd edition.

Milton, N. (2010). *The lessons llearn handbook: Practical approaches to learning from experiences*. Chandos Publishing, Oxford, UK.

Mingers, J. (2004). Real-izing information systems : critical realism as an underpinning philosophy for information systems. *Information and Organization*, 14:87–103.

Morris, M. W. and Moore, P. C. (2000). The lessons we (don't) learn: Counterfactual thinking and organizational accountability after a close call. *Administrative Science Quarterly*, 45(4):737–765.

Nagasundaram, M. and Bostrom, R. P. (1994). The structuring of creative processes: Implications for GSS research. In *Proceedings of the TwentySeventh Annual Hawaii International Conference on System Sciences*, volume 4, pages 51–60. IEEE.

Narayanaswamy, R. and Grover, V. (2007). A critical assessment of information systems action research. In Kock, N., editor, *Information systems action research - An applied view of emerging concepts and methods*, chapter 14, pages 327–354. Springer Verlag, New York, NY.

Newell, S. M., Bresnen, M., Edelman, L. F., Scarbrough, H., and Swan, J. (2006). Sharing knowledge across projects: Limits to ICT-led project review practices. *Management Learning*, 37(2):167–185.

Nijstad, B. A. (2009). *Group performance*. Psychology Press, Hove, United Kingdom.

Nolting, H.-P. and Paulus, P. (2011). *Psychologie lernen: Eine Einführung und Anleitung*. Beltz Verlag, Weinheim, Germany.

Object Management Group (2011). Business process model and notation (BPMN), version 2.0. Retrieved from http://www.omg.org/spec/BPMN/2.0/. Last accessed on August 15, 2016.

Paranagamage, P., Carrillo, P., Ruikar, K., and Fuller, P. (2012). Lessons learned practices in the UK construction sector: current practice and proposed improvements. *Engineering Project Organization Journal*, 2(4):216–230.

Patomäki, H. and Wight, C. (2000). After positivism? The promises of critical realism. *International Studies Quarterly*, 44:213–237.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior and Human Performance*, 16(2):366–387.

Petter, S. and Vaishnavi, V. (2008). Facilitating experience reuse among software project managers. *Information Sciences*, 178:1783–1802.

Pighin, S., Byrne, R. M. J., Ferrante, D., Gonzalez, M., and Girotto, V. (2011). Counterfactual thoughts about experienced, observed, and narrated events. *Thinking & Reasoning*, 17(2):197–211.

Plum, N. (2006). *Ein Beitrag zum Wissens- und Erfahrungsmanagement: Entwicklung einer Leitfragenstruktur für Erfahrungsberichte und ihre experimentelle Überprüfung*. PhD thesis, Universität Hamburg, Hamburg, Germany.

Princeton University "About WordNet" (2010). Wordnet. http://wordnet.princeton.edu. Last accessed on March 17, 2015.

Project Management Institute (PMI) (2004). *A guide to the project management body of knowledge: PMBOK guide*. Project Management Institute, Inc., Newtown Square, PA, 3rd edition.

Rheinberg, F. (2004). *Motivationsdiagnostik*. Hogrefe Verlag GmbH & Co. KG, Göttingen, Germany.

Rheinberg, F. and Vollmeyer, R. (2011). *Motivation*. Kohlhammer, Stuttgart, Germany, 8th edition.

Roese, N. J. (1997). Counterfactual thinking. *Psychological Bulletin*, 121(1):133–48.

Roth, P. L., Switzer, F. S. I., and Switzer, D. M. (1999). Missing data in multiple item scales: A Monte Carlo analysis of missing data techniques. *Organizational Research Methods*, 2(3):211–232.

Saldana, J. (2009). *The coding manual for qualitative researchers*. Sage Publications, Thousand Oaks, CA.

Sayer, A. (1992). *Method in social science: A realist approach*. Routledge, New York, NY, 2nd edition.

Schermerhorn, J. R. J., Osborn, R. N., Hunt, J. G., and Uhl-Bien, M. (2012). *Organizational Behavior*. John Wiley & Sons, Hoboken, NJ, 12th edition.

Schindler, M. and Eppler, M. J. (2003). Harvesting project knowledge: A review of project learning methods and success factors. *International Journal of Project Management*, 21(3):219–228.

Senge, P. M., Kleiner, A., Roberts, C., Ross, R., and Smith, B. (1994). *Fifth discipline fieldbook: Strategies and tools for building a learning organization*. Crown Business, New York, NY.

Simon, H. A. (1977). *The new science of management decision*. Prentice Hall, Upper Saddle River, NJ.

Smith, J. R., Terry, D. J., and Hogg, M. A. (2007). Social identity and the attitude-behaviour relationship: Effects of anonymity and accountability. *European Journal of Social Psychology*, 37(2):239–257.

Stauffer, D. (1999). Why people hoard knowledge. *Across the Board*, 36(8):16–21.

Steel, P. and König, C. J. K. (2006). Integrating theories of motivation. *Academy of Management Review*, 31(4):889–913.

Sternberg, R. J. (1995). Expertise in complex problem solving: A comparison of alternative conceptions. In Frensch, P. A. and Funke, J., editors, *Complex problem solving – The European perspective*, pages 295–321. Psychology Press, Hove, United Kingdom.

Sutter, M. (2009). Individual behavior and group membership: comment. *American Economic Review*, 99(5):2247–2257.

Swan, J., Scarbrough, H., and Newell, S. M. (2010). Why don't (or do) organizations learn from projects? *Management Learning*, 41(3):325–344.

Tamuz, M., Franchois, K. E., and Thomas, E. J. (2011). What's past is prologue: Organizational learning from a serious patient injury. *Safety Science*, 49(1):75–82.

Tan, H. C., Anumba, C. J., Carrillo, P. M., Bouchlaghem, N., Kamara, J. M., and Udeaja, C. (2010). *Capture and reuse of project knowledge in construction*. Wiley-Blackwell, Oxford, United Kingdom.

Tan, H. C., Carrillo, P. M., Anumba, C., Kamara, J. M., Bouchlaghem, N., and Udeaja, C. (2006). Live capture and reuse of project knowledge in construction organisations. *Knowledge Management Research & Practice*, 4(2):149–161.

USAID (2012). *After-action review (AAR) guidance*. USAID. https://usaidlearninglab.org/library/after-action-review-aar-guidance-0 (Last access: 29 August, 2016).

Valacich, J. S., Jessup, L. M., Dennis, A. R., and Nunamaker, J. F. (1992). A conceptual framework of anonymity in group support systems. *Group Decision and Negotiation*, 1(3):219–241.

van Duyne, D. K., Landay, J. A., and Hong, J. I. (2007). *The design of sites*. Prentice Hall, Upper Saddle River, NJ, 2nd edition.

van Grinsven, J. H. M. (2007). *Improving operational risk management*. Phd thesis, Delft University of Technology.

van Herk, H., Poortinga, Y. H., and Verhallen, T. M. M. (2004). Response styles in rating scales: Evidence of method bias in data from six EU countries. *Journal of Cross-Cultural Psychology*, 35(3):346–360.

Von Zedtwitz, M. (2002). Organizational learning through post-project reviews in R&D. *R&D Management*, 32(3):255–268.

Voss, J. (2007). Tagging, folksonomy & co - Renaissance of manual indexing? In *Proceedings of the 10th International Symposium for Information Science, Cologne*. Pre-print version. Retrieved March 18, 2015, from the arXiv database.

Voss, J. F., Greene, T. R., Post, T. A., and Penner, B. C. (1983). Problem-solving skill in the social sciences. *Psychology of Learning and Motivation - Advances in Research and Theory*, 17(C):165–213.

Vroom, V. H. (1964). *Work and motivation*. John Wiley & Sons, New York, NY.

Ward, S. (2003). Transforming project risk management into project uncertainty management. *International Journal of Project Management*, 21:97–105.

Weber, R. O., Aha, D. W., and Becerra-Fernandez, I. (2001). Intelligent lessons learned systems. *Expert Systems with Applications*, 20(1):17–34.

Wheeler, B. C. and Valacich, J. S. (1996). Facilitation, GSS, and training as sources of process restrictiveness and guidance for structured group decision making: An empirical assessment. *Information Systems Research*, 7(4):429–450.

Wiewiora, A. and Murphy, G. (2015). Unpacking 'lessons learned': investigating failures and considering alternative solutions. *Knowledge Management Research & Practice*, 13:17–30.

Williams, T. (2003). Learning from projects. *Journal of the Operational Research Society*, 54(5):443–451.

Williams, T. (2004). Identifying the hard lessons from projects – easily. *International Journal of Project Management*, 22(4):273–279.

Williams, T. (2008). How do organizations learn lessons from projects - and do they? *IEEE Transactions on Engineering Management*, 55(2):248–266.

Wu, J.-H. and Wang, Y.-M. (2006). Measuring KMS success: A respecification of the DeLone and McLean's model. *Information & Management*, 43(6):728–739.

Yin, R. K. (2008). *Case study research: Design and methods*. Sage Publications, Thousand Oaks, CA, 4th edition.

Curriculum Vitæ

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