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KNOWLEDGE CO-CREATION PROCESS AND FACILITATION OF TEMPORARY EXPERT GROUP IN VIRTUAL CONCEPT DESIGN

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ABSTRACT

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The first objective of this qualitative study is to create a holistic view of knowledge co-creation as a process by closely examining a virtual project during which a temporary group of cleantech experts co-create a conceptual design. The second objective is to identify experts' needs and project leaders' actions related to facilitation during the process, as well as to understand what kind of support is needed in virtual project environment in order to execute rather short-term and fast-paced co-creation projects.

Findings indicate that a knowledge co-creation process has two main phases; an unbounded phase and a solution-oriented phase. At first, problem framing is left rather open enabling effortless knowledge communication, and creating a shared, rich knowledge basis for the dispersed group. The group moves from open ideation to solution-oriented co-creation in which experts contribute to the emerging solution under increasing awareness of context and coherence. Project leaders have a significant facilitative role throughout the co-creation process. Virtual project environment offers opportunities for flexible collaboration projects, but is also a challenging context in which versatile support is needed.

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Tämän kvalitatiivisen tutkimuksen ensimmäinen tavoite on luoda kokonaisvaltainen kuva tiedon yhteiskehittämisestä prosessina seuraamalla tarkasti virtuaalista projektia, jonka aikana väliaikainen ryhmä cleantech -alan asiantuntijoita luo yhdessä konseptisuunnitelman. Toinen tavoite on tunnistaa asiantuntijoiden tarpeita ja projektinvetäjien toimenpiteitä liittyen fasilitointiin prosessin aikana, sekä ymmärtää millaista tukea virtuaalisessa projektiympäristössä tarvitaan melko lyhytkestoisten ja nopeatempoisten yhteiskehittämisprojektien toteuttamiseksi.

Tulokset näyttävät tiedon yhteiskehittämisen prosessissa olevan kaksi vaihetta; rajoittamaton vaihe ja ratkaisukeskeinen vaihe. Ensin ongelman rajaaminen jätetään melko avoimeksi, mikä mahdollistaa vaivattoman tiedon kommunikoinnin, ja hajautuneelle ryhmälle yhteisen, rikkaan tietopohjan luomisen. Ryhmä siirtyy avoimesta ideoinnista ratkaisukeskeiseen yhteisluomiseen, jossa asiantuntijat myötävaikuttavat ratkaisun syntymiseen tiedostamalla selkeämmin kontekstin ja koherenssin. Projektinvetäjillä on merkittävä fasilitoiva rooli läpi yhteiskehittämisprosessin. Virtuaalinen projektiympäristö tarjoaa mahdollisuuksia joustaville yhteistyöprojekteille, mutta on myös haastava konteksti, jossa tarvitaan monipuolista tukea.

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1 INTRODUCTION

Already 25 years ago Engeström (1992, 24-26) anticipated that work and expertise will be increasingly much performed in multi-professional teams and networks. He suggested that transition of work and expertise could be described by increasing flexibility and collectivity. Today, advanced ICT technology and virtual collaboration environments create an intriguing opportunity for businesses to bring the best talents together despite geographical distances between the people. There are many forms of co-creation ventures offering businesses and their networks of actors significant opportunities for innovation (Frow et al. 2015, 463, 471). Increasingly companies utilize distributed teams to leverage their resources and address diverse markets (Majchrzak et al. 2005).

Terminology of groups and work arrangements within virtual project environment is versatile due to a relative long existence of technology-mediated collaboration in its earlier and later forms. Virtual teams, virtual organizations, and virtual professional communities, all describe the same phenomenon from different perspectives, and sometimes these terms are used even as synonyms. Lipnack and Stamps (2000, 70) describe a virtual team as a highly adaptive organization capable to handle change and complexity, being a quicker, smarter, and more flexible work group. Santoro and Bifulco (2008, 280-281) call a virtual team as a temporary aggregation of professional virtual community members addressing to specific business opportunity.

Virtual projects, temporary groups and the related opportunities are studied in the present thesis from the perspective of knowledge co-creation of dispersed experts. In the process, new knowledge is created in the synthesis of differing views held by experts with different backgrounds. Although ideas are formed in the minds of individuals, they are usually developed in interaction between persons (Nonaka 1994, 15). When individuals with different expertise, knowledge and experience are brought together, they get exposed to new paradigms and perspectives, leading to cross-fertilization of ideas (Van Der Vegt & Bunderson 2005, 534).

It is known that participants in distributed collaboration have to deal with spatial and temporal boundaries (Cummings et al. 2009), and dialogical challenges related to knowledge sharing, questioning ideas and developing new solutions (Fayard & Metiu 2014). Knowledge differences between team members may impede the work by making integration difficult (Majchrzak et al. 2012). For projects to be successful and beneficial for both experts selling their knowledge and clients buying an outcome of their expertise, more understanding of a knowledge co-creation process of a temporary group of experts is needed.

The present thesis aims to enhance the understanding about knowledge co-creation process, and its facilitation, in virtual project environment. Solved network of cleantech experts forms the empirical context of the study. In addition to a case study of one virtual concept design project, several members of the network are interviewed for adding perspective on facilitation aspects. The thesis is a part of the research project INNOSPRING CATCH –capturing opportunities and co-creating value in the digital economy.

1.1 Research problem and statement of purpose

The purpose of this research is to study how selected experts, working at a distance from each other, communicate and integrate knowledge to achieve a shared knowledge creation goal, which is a conceptual design solution in the empirical case. The aim is to create understanding of a temporary expert group's knowledge co-creation and describe it as a process model. Moreover, the aim is to understand the context of virtual project environment, in which interactions are mostly technology-mediated and working groups temporary, and to identify participators' needs for facilitation and support.

Therefore, the following research problem is formulated:

How a temporary group of experts co-creates knowledge in virtual project environment, and how is the process facilitated?

Hence, the research problem contains two parts; a **knowledge co-creation process** (1) and its **facilitation** (2).

1.2 Key definitions

Virtual project environment. By this I mean the temporary nature of virtual work. In this context, the work unit can be called a virtual team, which consists of individuals of varying employment statuses that work for a common project (Crossman & Lee-Kelley 2004, 377). Members of a virtual team do not work in either the same place and/or at the same time, and therefore must rely on communication technology instead of constant face-to-face collaboration (Schweitzer & Duxbury 2010, 274). In the present thesis, the co-creation group of experts operates in a virtual project environment and satisfies the above-mentioned definitions of a virtual team.

***Knowledge co-creation process*.** A sequence of individual and collective communicative actions of sharing and integrating knowledge. The process by nature is evolving and iterative rather than linear.

Knowledge communication. An activity interactively (through face-to-face or technology-based communication) convey and co-construct insights, assessments and experiences through verbal and non-verbal means. Knowledge communication can happen synchronously (real-time interaction), also called as knowledge dialogues, or asynchronously as delayed interaction. (Eppler 2006, 317) Knowledge communication, a close term to knowledge sharing, is a necessary part of knowledge integration and creation. Ideally, a piece of knowledge an individual communicates is understood and reacted by another individual, but naturally messages are not always successfully communicated and interpreted.

Knowledge integration. Knowledge possessed by individuals gets enriched at the collective level. Integration of individual knowledge is a fundamental activity of groups (Okhuysen & Eisenhardt 2002, 370). Expertise integration is the process of jointly applying specialized knowledge held by team members at the project level by

recombining individual expertise (i.e., tacit knowledge of individuals, according to Panahi et al. 2013, 381) to develop project concepts, designs and solutions (Tiwana & McLean 2005, 15).

Knowledge co-creation facilitation. "Facilitation is a process through which a person helps others complete their work and improve the way they work together" (Weaver and Farrell 1997, 3). In the context of a knowledge co-creation process, facilitative actions of project leaders improve the way dispersed experts communicate and share knowledge to achieve a shared knowledge co-creation goal.

Boundary objects and artifacts. "The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds" (Star & Griesemer 1989, 393). There are many close terms and definitions of objects and artifacts inspired by the original concept. Particularly the ones that better fit to non-routine tasks and novel virtual collaborations, e.g., boundary negotiating artifacts (Lee 2007), and objects supporting cross-disciplinary collaboration (Nicolini et al. 2012) are considered in the present thesis.

Concept designing. One type of a knowledge creation task, in which concepts are created to solve problems. Knowledge creation and integration are the goal of the co-design process, in which actors from different disciplines share their knowledge about both the design process and the design content (Kleinsmann & Valkenburg 2008, 370-371). The aim of concept designing can be to create new strategic level solutions, to develop more concrete solutions, or the design work can cover the whole process moving from abstract to more concrete level. The concept design process starts by asking "what" rather than "how". (Rosted et al. 2007, 44, 26, 158-169)

1.3 Structure of the thesis

In addition to the above mentioned key definitions, different views on knowledge and expertise are presented at the beginning of the theoretical part. After that, there are three main theoretical chapters; 1) Communicating knowledge in virtual project environment, 2) Creating knowledge through collective actions, and, 3) Leading knowledge co-creation.

First, the nature and challenges of knowledge communication in virtual project environment, including technology-mediated communication and knowledge sharing in the context of project environment, are described in chapter 2.2. It is followed by reviewing theories of knowledge creation, and concepts of boundary objects and artifacts. After that, the focus is on knowledge co-creation facilitation. Finally, the conceptual framework in chapter 2.5 ends the theoretical part of the thesis, and functions as the linkage between the literature review and the empirical study.

The research methodology is being introduced in the chapter 3. First the research strategy and design, including research questions, are presented. Then, the empirical setting is introduced. Finally the data collection, and the process of data analysis are explained in detail.

The research problem being twofold, also the empirical findings are presented in two parts. Findings regarding the knowledge co-creation process are presented in chapter 4.1, and findings regarding facilitation aspects are presented in chapter 4.2. The process model under discussion section in chapter 5.1 shows the key empirical findings. Research questions are likewise replied in the same chapter. Then, empirical findings are discussed in relation to existing research regarding knowledge sharing and creating in virtual context, as well as time-constrained group processes aiming for novel solutions.

Finally, aspects of quality and value of the study are evaluated. Also limitations of the study and suggestions for further research are discussed.

2 VIRTUAL KNOWLEDGE CO-CREATION

The theoretical part of the thesis starts by examining different views of knowledge and expertise. After that, the topic of virtual knowledge co-creation is approached from three perspectives, each forming one of the three main theoretical chapters. The first chapter discusses about technology-mediated communication and knowledge sharing in project environment. The second chapter concerns knowledge integration and new knowledge formation through interaction and using of boundary objects and artifacts. The third chapter is about leading knowledge co-creation through wide-ranging facilitation.

2.1 Knowledge and expertise

Types and functions of knowledge have been defined differently among different authors. One of the famous definitions is presented by Polanyi, who classified human knowledge into explicit, i.e., codified knowledge that can be easily transmitted, and tacit knowledge, i.e., personal quality of knowledge that is difficult to formalize and communicate (Nonaka 1994, 16). Nonaka (1994) extended the Polanyi's idea of tacit knowledge by proposing the division of tacit knowledge into cognitive and technical elements. Cognitive elements refer to mental models in human mind, such as perspectives, while technical elements include concrete know-how and skills that apply to specific contexts.

Expertise can be described to be an individual's tacit knowledge (Panahi et al. 2013, 381), or "the ability to act knowledgeably within a specific domain of application" (Gasson 2005, 3). Defining who is an expert, and who is not, is nevertheless obvious. The editors in the preface of the book *Sharing Expertise – Beyond Knowledge Management* (Ackerman, Pipek & Wulf 2003) described their view on expertise: "Expertise connotes relative levels of knowledge in people. Relatively few people will claim themselves to be experts, but many people agree they have some measure of expertise in some area." The accumulation of experience is a vital part of the process of becoming an expert (Cross 2004, 428).

There are different perspectives to view knowledge and expertise. Cognitive approach views knowledge as a “property” owned by an individual, and expertise as an individual’s competency. The other perspective, often called as practice-based approach, views knowledge as context-dependent “knowing” emerged in social interaction. Thus expertise, which can be considered as tacit knowledge, is linked to work practices and social interaction. Next, I open ideas of these two perspectives in more detail and then argue my point of view, which goes along with the authors who say the two views don’t need to be seen as mutually exclusive (e.g. Marshall 2008) appreciating ideas from both perspectives.

According to the traditional approach, expertise is seen to be possessed by an individual either as a competency developed through rigorous learning opportunities, or as a professionalism linked to legitimated practices and an expert status (Treem 2012, 24-25). Experts differ from novices not only based on the amount of domain specific knowledge they have, but also based on their ability to organize and use knowledge. In chess, for example, an experienced player has got familiar with the analogies of the game and knows the patterns of play, and is able to use stored knowledge to deal with emerging situations. (Kahney 1986, 140, 107)

As a comparative perspective, Brown and Duguid (2001) proposed to look at knowledge through practice, as embedded in the ways people engage in their tasks, jobs, or professions to get work done. By focusing on practice both sides of knowledge, “sticky vs. leaky”, “tacit vs. explicit”, or “know-how vs. know-that” can be appreciated, as “knowledge is two-dimensional and practice underpins its successful circulation” (ibid 2001, 204). Nicolini (2011) adds to the practice-based perspective by emphasizing the “site” of knowing, and taking into consideration materiality, spaces and time. Then, knowledge is manifested through moments of practice; both through the doings and sayings, and through interaction between human and non-human elements.

Moreover, Treem (2012) argues that considering expertise as a property of individuals, as it is held in the cognitive views, may not be accurate in knowledge-intensive settings. He raises an interesting question of how expertise of an individual is perceived by others in the work community, in which work practices are ill-defined, invisible and outputs ambiguous. He points out that in novel, complex or uncertain

situations it is difficult to validate the actual expertise performed, and therefore suggests a communicative view of expertise construction. As his findings indicate, when behaviours of individuals become visible in social interaction through communicative actions, others make judgements about whether the behaviours are attributions of expertise or not. Thus, according to this view, communication and social interaction act as determinants of expertise. This brings up an interesting challenge regarding expertise assessment in virtual project environment, which often lacks of nonverbal communication and therefore some elements of social interaction, in addition to work arrangements being sometimes very short-term.

Marshall (2008) argues that there can be a productive dialogue between the cognitive and the practice-based perspectives, and that “acknowledging a cognitive dimension to knowing does not have to be incompatible with a socially situated, constructionist and processual view” (ibid 2008, 414). In a similar vein, Okhuysen and Eisenhardt (2002, 384), while arguing their view on knowledge integration, accept ideas from both “knowledge as resource” and “knowledge as knowing” views.

I think ideas from both perspectives should be taken into consideration when thinking about a temporary group of experts co-creating knowledge during a project. Dismissing ideas of the cognitive perspective would question buying the working hours from the experts instead of novices. The shorter the project is, the more the outcome relies on the knowledge possessed by individual project members. Experts are hired because not any group of individuals could solve the problem or come up with the solution, particularly in a short time. Naturally, experts utilize the skills and know-how they have gained before. Just as Schön (1988, 182) said about designers; they develop knowledge in one design episode and carry it over to the next one, and thus build up their knowledge in a cumulative fashion.

Despite of this, knowledge integration is not as simple as assembling discrete pieces of knowledge like Lego blocks, but it depends on individuals, and how they know and integrate the knowledge they have (Okhuysen & Eisenhardt 2002, 383-384). The same group of experts may end up in a completely different solution depending on which knowledge they focus on, which direction they take, and from which perspective they look at the situation, thus implying that the collective value of knowledge resources can be increased through alternative combinations, i.e.,

different ways of knowing in the situation (Okhuysen & Eisenhardt 2002, 384). This also means that project leaders have a significant role in facilitating experts' collaboration and guiding their discussions to a right direction, as will be presented in the empirical findings.

2.2 Communicating knowledge in virtual project environment

Virtual project environment, despite of providing great opportunities for multiple types of collaboration ventures, is a challenging context for knowledge communication for two reasons. Firstly, in virtual environment communication is technology-mediated with no face-to-face interaction in the same physical space. Virtual communication can be fast and effective, but the lack of a full-scale body language may diminish shared understanding. Secondly, project environment brings along temporary work assignments, which may increase feeling of uncertainty. In short-term projects with unfamiliar people experts may feel cognitively challenging or unmotivated to share "all they know".

2.2.1 Technology-mediated communication

In technology-mediated, or computer-mediated communication, much of the verbal output is replaced by textual output. The benefit is reprocessability, the extent to which one can re-examine or reprocess the message, and connect it to messages sent earlier and stored in an archive. (Baralou & Tsoukas 2015) Digital platforms are increasingly used to support dispersed teams' communication and collaboration. Platforms are adopted mostly to replace dissatisfying features of traditional email and to better support virtual collaboration. Features of platforms are considered to bring knowledge benefits, e.g., in facilitating information searching and organizing whereas email is seen to impede communication and knowledge sharing. (Anders 2016) Synchronicity, the extent to which a medium enables participants to communicate at the same time, is low in email-assisted communication, whereas it

is high in teleconferencing (Baralou & Tsoukas 2015). Asynchronous communication has been said to be a barrier to problem solving and decision making (Rosen et al. 2007, 264). However, in some cases it can bring positive simplicity or straightforwardness to discussions between project members. The need to actually write one's sayings forces the person to express perspectives and opinions in brief, diminishing unnecessary pondering known from traditional meetings.

But not any knowledge in all types of situations is easy to share through technology-mediated communication. Sharing an emerging idea, when it actually still is more like a hunch or an intuition in one's mind, can be tricky even in a face-to-face situation with a friend, not to mention a virtual context when one has to explain the idea to unfamiliar people by writing it on a digital platform. There has been a lot of scepticism towards tacit knowledge sharing in virtual context in earlier research. According to Nonaka et al. (2000, 16) tacit knowledge, such as experiences, feelings, emotions and mental models are best shared in direct, face-to-face interaction between people. Hislop (2002, 174), on behalf, argues that all knowledge has both tacit and explicit elements and therefore sharing any knowledge through technology is problematic. Despite of the rapid technological development, it is still easy to agree with Hislop (2002) on his notion that contextual factors affect the likelihood of sharing knowledge successfully in virtual context. These contextual factors include the relative high degree of explicitness of knowledge (knowledge that can be easily expressed in words, and does not require the missing senses, for example, touching), the significant degree of common knowledge between the participants, as well as the degree of trust and opportunities for social interaction affecting the willingness to share the knowledge.

ICT and computer technology have developed rapidly in the 21st century. While admitting some aspects of social interaction are inevitably still lacking in virtual interaction, one might think that physical, face-to-face interaction is not anymore absolutely necessary for sharing tacit knowledge between individuals. Describing virtual media as memos, emails and teleconferences, as an opposite of face-to-face interaction (Nonaka et al. 2000, 16) does no longer accurately describe the existing virtual communication and collaboration possibilities. There are other features, such

as video connection and screen sharing, very broadly accessible. Also more advanced 3D virtual worlds are growing popularity as a collaboration technology for distributed teams, and can increase feeling of co-presence and foster team creativity (Alahuhta et al. 2014).

2.2.2 Sharing knowledge in project environment

Even if expertise knowledge could be shared through technology and relatively quickly as required in temporary virtual collaboration, there is a remaining question; in what conditions individuals are willing to share it? As knowledge is a competitive advantage not only for organizations but for individuals too, members of temporary teams potentially face a paradox. They know that only through knowledge-sharing the team is able to create new knowledge. However, they might not want to share their knowledge if fearing it creates risks for them. (Malhotra & Majchrzak 2004, 84; Stenmark 2000, 21)

Related to dispersed collaboration a lot has been talked about how team members feel about being physically distant from each other. Many similar terms; a sense of personal connection or personal bond (Nemiro 2000), a sense of co-presence (Alahuhta et al. 2014), a sense of social engagement (Anders 2016), and a sense of perceived proximity (O'Leary et al. 2014) have been used to discuss the importance of feeling connected, or "being together" with the distant team members. Communication is important in creating this kind of a connection, as communication can carry "symbols of closeness", such as showing one's commitment to shared work goals and demonstrating one's dependability (O'Leary et al. 2014, 1235). Developing a personal connection can also be contributed by face-to-face get-togethers, shared humor, by sharing personal information, or it can be formed when a team functions as a supportive network for each other (Nemiro 2000, 114-115). Accordingly, objective distance between collaborative participants does not automatically imply how close or distant they feel one another, i.e., the cognitive and affective sense of relational closeness can be the same in dispersed work relationships than in collocated work relationships (O'Leary et al. 2014).

Pipek, Hinrichs and Wulf (2003) studied expertise sharing in a network organization, which offers training and consulting services, and consists of over two hundred entrepreneurs and freelancers. The organization, or community, act as a network of cooperative entities responding to market demands handling projects in a self-organized manner. Almost all interviewees, members of the network, responded to researchers that they would be willing to share self-produced materials to anyone in the network. However, replies to more detailed questions revealed that sharing expertise was not fully open or altruistic. Members were willing to share documents but wanted to know in which context the material would be used, to whom it would be shared, and if a financial compensation could be expected. Members, working in the large network where competition and cooperation coexisted, did not want to place their materials into a central repository, but preferred to have some control over their products of expertise in order to secure having mutual benefit and reciprocity of favors.

At its best, knowledge sharing can be very positive and active in project environment when individuals work in sequential and overlapping projects, learn from them, and transfer the gained knowledge to next projects in which, in return, new temporary colleagues can learn from it. When experts work in a project-based organization, or in temporary projects as freelancers, the “lessons learned” and knowledge gained in one project may help everyone in a parallel or an upcoming project. Fong (2003) calls this direct or indirect transfer of knowledge from one project to another as inter-project learning. Obviously there must be a certain degree of repetitiveness, for example in similar tasks or principles, between the projects to benefit the inter-project learning.

2.3 Creating knowledge through collective actions

Even if knowledge is “owned” by individuals, as suggested in cognitive views, it is necessary that individuals integrate their specialized knowledge in a group to realize its value. On that account, Okhuysen and Eisenhardt (2002, 370) call integration of individual knowledge as a fundamental activity of groups. The process of knowledge

and expertise integration includes not only sharing individually held knowledge to the group members but also utilizing it in the project context and combining it to create new knowledge (Tiwana & McLean 2005, 18; Okhuysen & Eisenhardt 2002, 371).

Integrating expertise of multiple sources requires overcoming obstacles related to knowledge embeddedness and tacitness (Levina & Vaast 2005, 336). In addition to human agents, such as project leaders and members, also objects play an active role in collaboration. Material and symbolic artifacts operate as mediators of social actions. (Nicolini et al. 2012, 623, 614) Boundary objects and artifacts can facilitate in creating new knowledge through collective actions by allowing individuals to represent their tacit knowledge in multiple formats, such as visual drawings. “Objects allow us both to act at a distance and to make our interaction endure beyond the present” (Nicolini et al. 2012, 613), and therefore they are particularly interesting in the context of virtual collaboration.

2.3.1 Creating knowledge through interaction and integration

Knowledge creation is commonly seen as an interaction between tacit and explicit knowledge. Nonaka (1994) presented the famous framework, later called a SECI model, according to which tacit and explicit knowledge can interact and create new knowledge. Figure 1 illustrates how knowledge is created by individuals in their interactions with each other and the environment through four knowledge conversion modes of socialization, externalisation, combination and internalization.

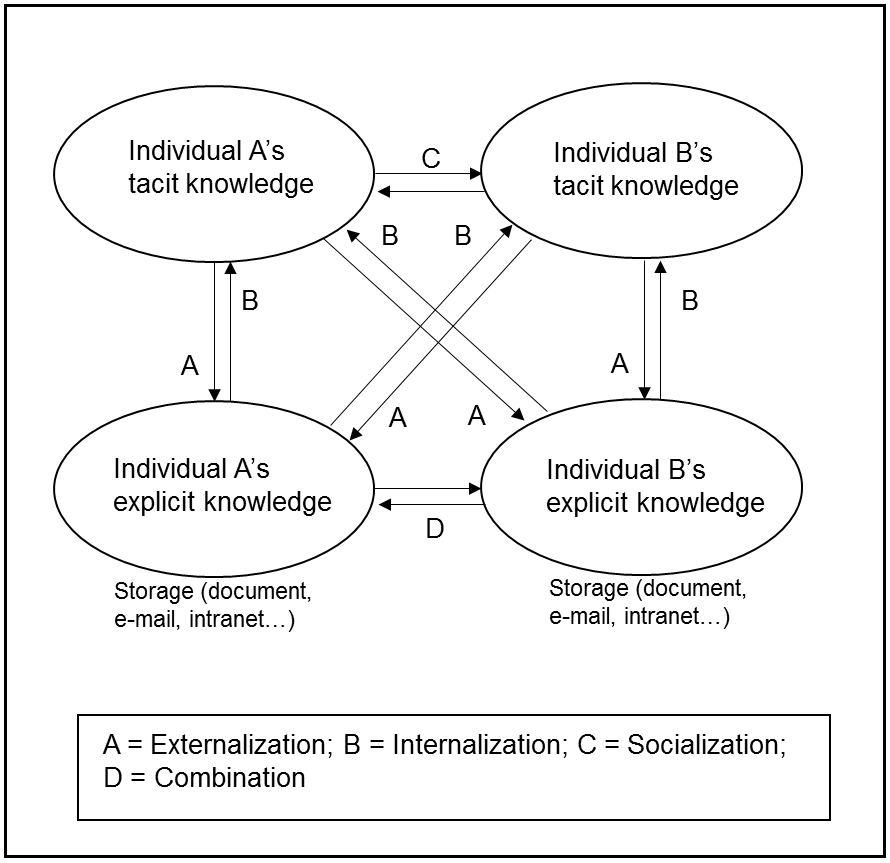

Figure 1 Nonaka's knowledge creation modes, as presented by Alavi and Leidner (2001, 117)

Socialization, conversion from tacit knowledge to new tacit knowledge, may start by forming a team of interaction (Nonaka 1994, 20). Socialization is described to occur by time and only among individuals through shared, direct experience engaging all five senses (Nonaka et al. 2008, 20), and thus it's a challenging concept in virtual project environment in which social interaction is technology-mediated and lacks of aspects of continuity when communication is asynchronous and collaboration temporary. New knowledge can also be created through *externalization*, which is a preferable concept to consider in virtual project environment. In this process, team members articulate own perspectives and reveal hidden tacit knowledge by converting individual tacit knowledge into explicit forms through language, images, or other representations, and then share it with the group (Nonaka 1994; Nonaka et al. 2008, 22). *Combination*, on behalf, takes place always when explicit knowledge is in some way processed to form new explicit knowledge, e.g., a piece of knowledge is added to the entity, or discrete pieces of knowledge are combined or

recategorized. The last mode, i.e., *internalization*, means converting explicit knowledge to tacit knowledge. Its idea is close to the concept of learning. (Nonaka 1994, 19) Connecting explicit knowledge to a specific context or to knowledge one possesses, requires effort of reflecting or putting into practice (Nonaka et al. 2008, 24).

Differences in individuals' viewpoints are necessary for knowledge creation. New knowledge is created in the synthesis of differing views held by a variety of people. (Nonaka et al. 2008, 8, 12) Expertise heterogeneity, diversity in the expertise possessed by team members, can lead to variety of ideas, and a number of linkages and associations among ideas (Tiwana & McLean 2005, 21). In a multidisciplinary team expertise diversity can refer to members' functional areas, such as engineering, marketing, and finance, or to more fine graded expertise distinctions, i.e., members' diverse specialties embedded in the common area of expertise (Van Der Vegt & Bunderson 2005, 533). Team members can borrow and recombine ideas and concepts from one domain to the other, and potentially turn existing project ideas into more creative ones (Tiwana & McLean 2005, 21). Differences in knowledge and expertise between project members is the core idea in co-creation projects aiming for novelty.

Despite of potentially being a value-bringing element, high level of expertise diversity in a group cannot simply be assumed to have positive influences in all circumstances (Tiwana & McLean 2005; Carlile 2004). Expertise heterogeneity may cause difficulties in reconciling diverse interpretations of project goals and perspectives on possible solutions, and thus impede the group's ability to reach consensus on proceeding (Tiwana & McLean 2005, 34). When differences in types and/ or amounts of domain-specific knowledge between group members increase, the amount of effort required to share and assess each other's knowledge also increases. This challenge exists in working environments with task interdependency. (Carlile 2004, 556-557)

Expertise integration in a team is facilitated by the relational capital, including trust, reciprocity and closeness of working relationships (Tiwana & McLean, 2005). Van Der Vegt and Bunderson (2005) highlight the importance of emotional component of social identification that supplies the motivational force. They argue and show

evidence that in teams with low levels of collective team identification, i.e., low emotional attachment to team membership, expertise diversity is negatively related to team performance. In the case of high collective team identification the same relationship is positive. However, they also point out that excessive diversity simply brings too much complexity in the form of different perspectives and opinions, creating an impossible mission to integrate diverse domains of expertise to collectively solve a problem. So, diversity in knowledge and expertise brings the necessary creative ingredients to collective knowledge creation but too much of diversity impedes co-creation.

Dialogue has a critical role in the knowledge transformation and integration process, particularly when a team faces a novel situation (Majchrzak et al. 2012, 964). Dialogue is an effective basis for knowledge creation because it enables individuals to understand that there are different views, which helps them to accept and synthesize these views (Nonaka et al. 2008, 32). Baralou and Tsoukas (2015) point out that authors should not assume dialogues to occur only in face-to-face contexts. More precisely, individuals engage in dialogical interactions with real others (people physically present), with invisible others (people appearing as ‘indices’, such as voices, images or words on screens) and with artifacts (created by people while carrying out their tasks, such as texts). The last mentioned form of interaction, artifacts, is presented more closely in the next chapter.

2.3.2 Boundary objects and artifacts in knowledge co-creation

Boundary object is a concept first introduced by Star and Griesemer (1989). Since then a large number of authors have applied the concept, and many of them also continued the work by proposing new concepts with alternative definitions. Some authors endorse similarities (e.g. Bergman et al. 2007, 547), while some authors rather argue about differences (e.g. Lee 2007), between their concept and the original concept. Going through all the different boundary object -related concepts, which have emerged since the inspiration sparked by the original concept, is not in the scope of this thesis.

Instead, I compare a few of the concepts (table 1), discuss at a general level how objects and artifacts affect knowledge co-creation, and then evaluate how they might be relevant regarding the empirical case of the present thesis. Artifacts are elaborated further, and in relation with boundary spanning activities, in chapter 2.4.3, which discusses the role of project leaders as knowledge co-creation facilitators.

Table 1 A few examples of objects and artifacts

Concept & Author(s)	**Definition(s)**	**Example(s)**	**Context & Role of objects or artifacts**
Boundary objects Star & Griesemer (1989)	"Objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (p. 393)	*Repositories* (e.g. a library or museum) *Ideal types* (an object such as a diagram) *Coincident boundaries* (common objects with same boundaries but different internal contents) *Standardized forms*	Development of a natural history research museum <u>Role:</u> Helping to manage both diversity and cooperation by inhabiting several intersecting social worlds and satisfying the informational requirements of each of them (p. 393)
Intermediary objects Boujut & Blanco (2003), the concept first suggested by Vinck & Jeantet (1995)	Intermediary objects characterise the deeply linked relationship between information, knowledge and medium of representation (p. 210)	CAD models, plans, sketchs	Engineering design process <u>Role:</u> Mediators helping to represent a product or a design process, and helping in process of transforming a product from one state into another state (p. 211)
Design boundary objects Bergman, Lyytinen & Mark (2007)	"Any representational artifact that enables knowledge about a designed system, its design process, or its environment to be transferred between social worlds and that simultaneously facilitates the alignment of stakeholder interests populating these social worlds by reducing design knowledge gaps" (p. 551)	proto-architectures project plans	SAD (System Analysis and Design research) process <u>Role:</u> Advancing design by promoting shared representation, transforming design knowledge, mobilizing for design action, and for legitimizing design knowledge
Boundary negotiating artifacts Lee (2007)	Boundary negotiating artifacts are used to, e.g., record, organize, explore and share ideas, as well as to create shared understanding about specific design problems (p. 333) "Are surrounded by sets of practices that may or may not be agreed upon by participants" (p. 333)	*Self-explanation artifacts* (e.g. notes, tables, concept sketches) *Inclusion artifacts* (e.g. sketches or text) *Compilation artifacts* (e.g. tables, technical sketches) *Structuring artifacts* (e.g. narratives, concept maps) *Borrowed artifacts*	CSWC (Computer supported collaborative work), multidisciplinary collaborative design of a museum exhibition <u>Role:</u> Facilitating the crossing of boundaries by transmitting information, and facilitating the pushing and establishing of boundaries by dividing labor (p. 333)

The concept of *boundary object* was developed by Star and Griesemer (1989) to help to understand how heterogeneity and cooperation were able to co-exist along the process of developing a natural history research museum. They found four types of boundary objects acting as temporary anchors or bridges between different social worlds, satisfying the informational requirements of each of them while providing the common structure for needed coherence. (ibid 1989, 393, 410, 414)

The excessive and varied use of the concept *boundary object* has led to some criticism remarking that not every artifact should be labelled as a *boundary object*, as when doing so, the power of the theory diminishes (e.g. Jalonen 2016, 37; Lee 2007; Nicolini et al. 2012). Star herself (2010) has not wanted to restrict the varied use of the concept, but she did reply to the broad discussion by later explaining the essential ideas behind *boundary objects*, and by giving examples of what they necessarily are not. As basically anything, e.g., a single word, could be considered as a *boundary object* in a certain context, Star (2010, 612) advised that they are most useful at organizational level.

Boujut and Blanco (2003, 210) propose a concept of *intermediary objects* applying it from Vinck and Jeantet (1995) to characterize the deeply linked relationship between information, knowledge and medium of representation. They describe that *intermediary objects* act in the same way as *boundary objects* but that they also are intermediate states of the future product (210-211). Collective design process requires participants to constantly explain the choices they make, or the modifications they propose to a CAD drawing, for instance. This gradually develops a common understanding of the design situation, i.e., the problem and the solution. *Intermediary objects* are representations allowing participators to express themselves, e.g., to point with a finger to an element on a drawing. (ibid 2003, 211-213)

Bergman et al. (2007) refer to Star & Griesemer (1989) when defining SAD artifacts as *design boundary objects*, which are “representational artifacts and associated ideas that enable design knowledge to be transferred between social worlds and that facilitate the alignment of their interests” (547). *Design boundary objects*, such as proto-architectures and project plans, were seen to facilitate shared understanding and promote agreements about designs by, e.g., being able to

connect design routines, to align stakeholder interests, as well as to identify and reduce gaps in design knowledge. (ibid 2007)

Standardization is integral to the definition of *boundary objects,* which are therefore problematic in contexts of non-routine and novel collaborations (Lee 2007, 310, 314). Responding to this call, Lee (2007) propose a concept of *boundary negotiating artifacts* while studying a newly formed interdisciplinary design group (314). This concept resonates with the *intermediary object* (333), but is more strictly separated from the *boundary object*. Lee (2007) describes five types of artifacts, which designers used to iteratively coordinate perspectives and to bring parties into alignment, at least temporarily, in order to solve specific design problems (318). *Structuring artifacts*, one type of the five *boundary negotiating artifacts*, are created to represent visions and expectations, to show the structure of the final design product, and to direct activities of others. Concept map, one type of a *structuring artifact*, was used as a tool for establishing a hierarchy of ideas by emphasizing ranking of topics with different sizes of bubbles. (325-331)

Despite the different contexts and definitions of the aforementioned concepts, all of them facilitate collaboration between people by providing the necessary knowledge to all participants allowing them to form a necessary level of shared understanding and at least a momentary agreement. *Boundary negotiating artifacts* are used, e.g., to record, organize, explore and share ideas, introduce concepts, augment brokering activities, and to create shared understanding about specific design problems (Lee 2007, 333). By allowing individuals to notice each other's tacit knowledge, including viewpoints, visions, opinions, perspectives and perceptions (Panahi et al. 2013, 381) boundary objects and artifacts can also reveal situations of being in false agreement. By this I mean situations in which members think they are in agreement, while in fact there are hidden differences in viewpoints, for instance, which are difficult to articulate but will become visible and potentially impede the design process at a later phase.

Sharing and understanding at a partial level that is sufficient for collaboration can be achieved by objects that allow similarities and differences to coexist (Nicolini et al. 2012, 624). As Lee (2007, 323) says about *boundary negotiating artifacts*, or more precisely *compilation artifacts*, e.g., tables and sketches, they can be used "to

bring two or more communities of practice into alignment just long enough to develop a shared and mutually agreeable understanding of a problem and to pass crucial information". In the study of Gasson (2005) a group of managers had different perspectives and expectations towards the new design of business process and IT systems support. This became very clear at the early stage of the process when managers provided very different kinds of charts and diagrams as design representations describing what the design should achieve. These differences were influenced by different domain backgrounds of managers. Although at the beginning dialogues were coloured by conflicts, using boundary objects of design representations and paper prototypes of the design allowed the group members to share tacit knowledge and to achieve a conceptual starting point.

By converting tacit mental models and emerging ideas into explicit concepts, or visual formats, boundary objects and artifacts provide to a co-creation group something, not necessarily concrete but less abstract, what they can refer to in their individual as well as collective thought processes. Nevertheless, a full consensus between experts in cross-disciplinary collaboration is not expected. After all, the original idea of *boundary objects* was created when it was noticed that consensus in heterogeneous groups is rarely reached, or fragile when reached, and still the collaboration continues, often without problems (Star 2010, 604).

There are similarities in all aforementioned boundary objects and artifacts, and each of them could be at least loosely applied to the empirical case of the present thesis. However, when the case's context (temporary collaboration in virtual project environment with a very low level of standardization in working methods and practices) is considered, then the traditional concept of *boundary objects* is not the best alternative. When thinking about the context and the knowledge co-creation task (concept design), then Lee's (2007) thoughts about using artifacts to explore and share ideas, and to create shared understanding about design problems in non-routine and novel collaboration, seem most applicable.

In the work of Nicolini et al. (2012) the discussion around boundary objects is extended by looking objects not only as boundary devices but also as epistemic things, objects of activities, and infrastructures. In the paper, different objects and artifacts are divided into three categories according to their role in cross-disciplinary

collaboration. Communication systems and primal documents are considered to be first level objects and artifacts, which constitute the basic sociomaterial infrastructure, and thereby have a necessary role in sustaining collaboration. (ibid 2012, 625) Drawing on these views, a virtual project platform, on which project members share and comment ideas and knowledge, can be considered to be one type of an object supporting collaboration. Thus, the ideas of Nicolini et al. (2012) are interesting to be considered when evaluating the role of virtual platform in the knowledge co-creation process of dispersed experts.

2.4 Leading knowledge co-creation

Collective knowledge formation is often cognitively, socially and emotionally more demanding process than working alone (Parviainen 2006, 165), and it unlikely gets any easier when the collaboration venture is temporary, fast-paced and solely virtual. Facilitation actions of project leaders are needed in the challenging context. Moreover, different kinds of objects and artifacts facilitate geographically dispersed experts, with distinct knowledge areas, in their co-creation actions.

2.4.1 Facilitation of co-creation

Weaver and Farrell (1997, 3) describe facilitation as “a process through which a person helps others complete their work and improve the way they work together”. Applying this definition, facilitating a co-creation group includes two interrelated points of view; one being task-centred and emphasizing factors facilitating group process and performance, and the other being people-centred and emphasizing factors facilitating collaboration between members.

Starting with task-centred factors, a collective understanding of the task at hand is formed through a process of structuring and formulating a problem (Cross 2004, 439). With design tasks, experts frame a problematic design situation by setting its boundaries, choosing particular things and relations to pay attention to, and impose

on the situation a coherence that guides the following actions. References function as specific guides to designing. They can be used to generate or justify a leading idea, which triggers a sequence of following actions. (Schön 1988, 182, 186-187) By referring to something that people already know makes the cognitive process easier. However, formulating a single fixed problem reduces opportunities, as problem solvers can only search for solutions that fit the problem definition (von Hippel and von Krogh 2016). Thereby, a co-creation group performance is facilitated by balancing with a sufficient but not too strict task definition, and by a moderate use of known references.

Time constraints and deadline pressures have been recognized as barriers to information and knowledge sharing in virtual teams (Rosen et. al 2007). Inefficient knowledge sharing, such as information arriving too late and ongoing changes in documents, hinders a project group's shared understanding (Kleinsmann et al. 2010). When it is not known whether a piece of information will be accurate for the project a week later, an individual easily decides that it is not worthwhile to make an effort and record all the data, as some knowledge may be perceived to only have ”transient utility” (Rice et al. 2000, 94).

Indeed, finding a balance in providing enough information without causing an information overload is a challenge. Therefore, norms for communicating and exchanging information are applied in many virtual teams. (Nemiro 2000, 114) Keeping all project members updated on goals, priorities, and activities, is vital to successful collaboration (Rosen et al. 2007, 269), and an important action of project leaders facilitating a group process and performance. A certain adaptation process from misaligned expectations and pre-existing structures to changes made in group's norms and practices, is likely to occur in a newly formed virtual group without members sharing working history (Majchrzak et al. 2000). Naturally, when the lifespan of the co-creation group is short, there is less room for adaptation and improvements to be made.

Moving to more people-focused factors facilitating collaboration between group members, the fundamental role of trust in business relationships and in collaboration has been widely recognized for a long time (Child 2001; Smith et al. 1995). Trust increases the willingness to overcome cultural differences, to cope with unforeseen

circumstances and to work through emerging difficulties. Trust is necessary for successful teamwork and new knowledge creation. (Child 2001, 277-279) Psychologically safe communication climate, including support, openness, trust, mutual respect and risk taking, facilitates team's collaboration (Gibson & Gibbs 2006). Virtual project leaders can facilitate knowledge sharing by promoting a psychologically safe team culture in which members feel confident to share ideas, give constructive criticism, and ask help from other members when needed (Rosen et al. 2007, 267).

Traditional nature of trust is based on shared experiences and similarities, such as belonging to the same social group, sharing education, or sharing a long working history together. Generating mutual trust between team members not knowing each other beforehand is particularly important (Child 2001, 276, 278) but challenging for a team which is formed quickly to complete a complex, time-pressured project (Wildman et al. 2012; Majchrzak et al. 2007). In the context of temporary groups described by velocity, uncertainty and a lack of knowing each other in the group, Meyerson et al. (1996) suggested a term of swift trust, which ever since has been adopted by a wide range of authors, e.g., Majchrzak et al. (2007), Child (2001), Kanawattanachai and Yoo (2002) Järvenpää and Leidner (1999). Swift trust is more about doing than relating, driven by a cognition and action rather than by personalities and interpersonal relations (Meyerson et al. 1996), and thus it is closely connected to the task-centred point of view emphasizing the group process.

Learning about backgrounds, experience and expertise of group members enables knowing "who knows what" (Rosen et al. 2007, 267, 269), which helps individuals to predict each other's perspectives, to locate sources of information, and to divide tasks according to each member's expertise (Gasson 2005, 5). According to past research of virtual groups, having a face-to-face contact at the beginning of collaboration has many benefits, including creating a shared language (Rice et al. 2000, 92-93), developing a personal bond between members (Nemiro 2000, 115), and moving rapidly to the actual performing stage increasing the likelihood of meeting project deliverables within objectives of time, cost and quality (Lee-Kelley et al. 2004, 654). So, an initial face-to-face meeting may facilitate co-creation group members to better work together and complete the work virtually.

2.4.2 Boundary spanning and using of artifacts

Objects and artifacts, such as drawings (Lee 2007), PowerPoint slides (Nicolini et al. 2012), and project plans (Bergman et al. 2007) allow co-creation participants to turn their ideas into “talkables”, and the group to move from individual cognitive processes to social group processes (Nielsen 2012, 106). Objects and artifacts are not stable nor pretermined, but rather fluid and anchored in processes and practices (Lee 2007; Nicolini et al. 2012). How a particular object supports collaboration depends more on its relations with other objects and other aspects of the activity than object’s essential characteristics (Nicolini et al. 2012, 626). According to Levina and Vaast (2005) artifacts become boundary objects-in-use only when they are used by all experts, when they make sense to all of them despite their different contexts, and when there is a joint field allowing them to have a common vision of the meaning of that artifact in the project.

So, although certain artifacts are more likely than others to become objects of collaboration, one should not assume that certain artifacts, such as drawings, repositories or standardized forms, would automatically serve the purpose (Nicolini et al. 2012, 626). Boundary objects are often talked together with boundary-crossing or boundary-spanning activities (Levina & Vaast 2005). Fong (2003) proposed that the first step in knowledge creation process of multidisciplinary project group is boundary crossing. Expertise boundaries between project members can be crossed through knowledge redundancy and boundary objects. There may be also hierarchical boundaries in case clients, or other stakeholders, are involved in the project. Group members can consciously break down barriers by valuing the expertise of others. Boundary crossing does not guarantee successful knowledge creation but builds a premise and thus facilitates the upcoming knowledge processes of multidisciplinary project group. (ibid 2005, 483-484)

A holistic, multi-perspective approach to different objects and artifacts can be valuable when willing to understand how they can facilitate shared understanding between experts throughout a co-creation project in its different phases and steps. Inspired by the work of Wartofsky (1979), Nicolini et al. (2012) organized different types of work objects into a three-level hierarchy according to how objects support

cross-disciplinary collaboration. The first level objects, such as buildings, communication systems and project plans, provide the basic infrastructural support for collaboration. The second level objects carry the most traditional characteristics of boundary objects and can facilitate collaboration across different types of boundaries. Most of the commonly referred boundary objects would fall into this category, including norms and routines. The third level objects have the power to trigger and motivate collaboration. These objects are derived from the theories of epistemic objects and cultural historical activity theory, and thus are often ignored when studying objects and artifacts only from the theoretical perspective of boundary objects. Nicolini et al. (2012) suggested that objects can change status during a project, and that different types of objects are more useful in different stages of collaboration, e.g., primary objects, such as, a vision, can mobilize commitment at the early stages of collaboration. As objects can mean different things to different people, they can also create misunderstandings and tensions. It is not enough to consider what objects with which characteristics are used, but also when they are used, and how people interpret them, i.e., what roles they carry to different people. (Nicolini et al. 2012)

2.5 Conceptual framework

Conceptual framework (figure 2) summarizes the theoretical part of the thesis and forms the perspective for the empirical study. Virtual project environment creates a specific kind of a context for collaboration and knowledge creation. A temporary group of experts collaborate at a distance from each other, sharing and integrating diverse knowledge to achieve a joint knowledge creation goal.

Through the empirical study, I aim to create more understanding of knowledge co-creation as a process, and its facilitation, in the context of virtual project environment. More specifically, the purpose is to understand how dispersed experts share and integrate knowledge during the process, how project leaders act to facilitate it, as well as what contextual challenges and facilitation needs participants of virtual co-creation process identify.

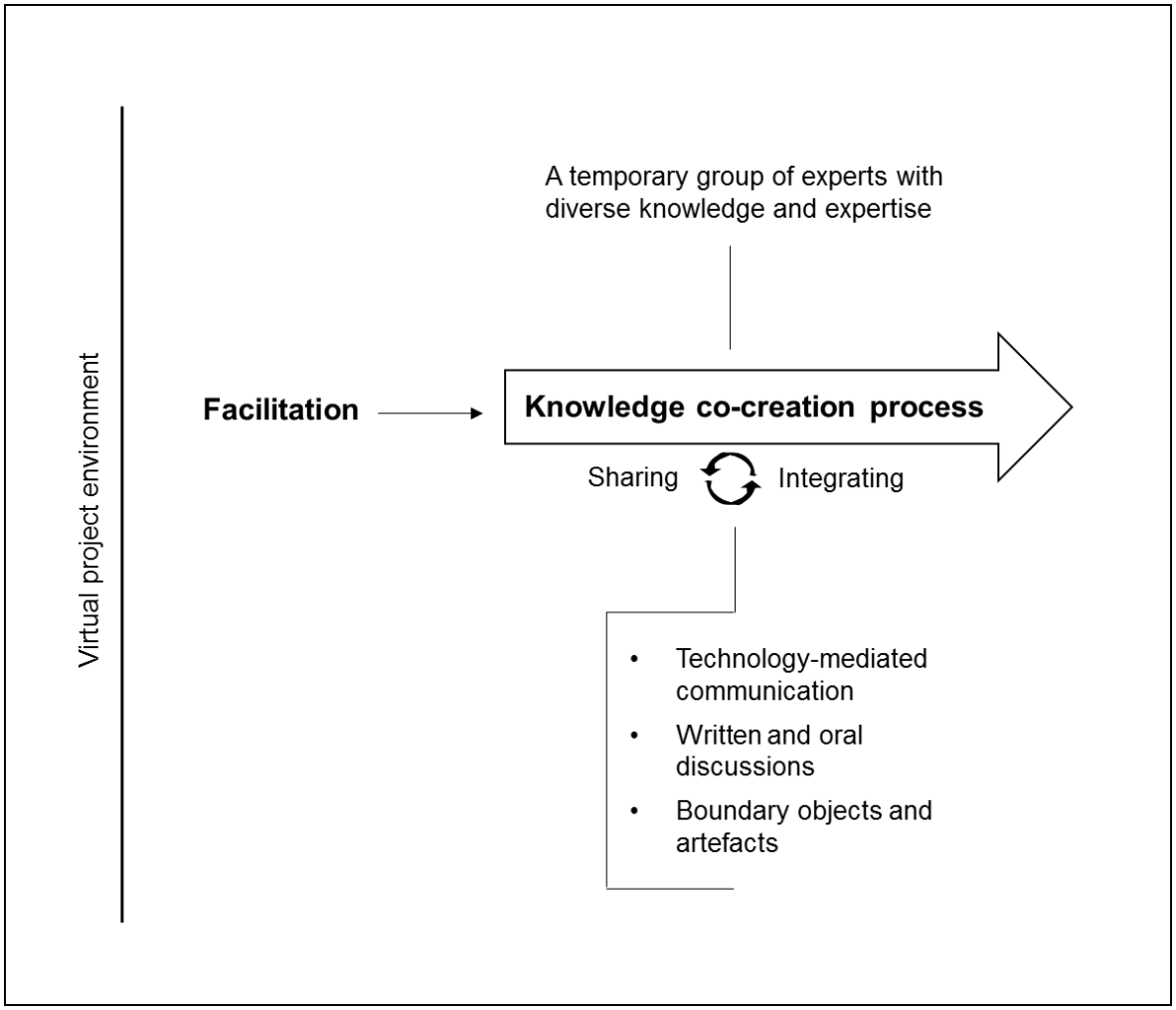

Figure 2 Conceptual framework of the thesis

3 RESEARCH METHODOLOGY

The research problem, or the main research question, of the thesis is: ***How a temporary group of experts co-creates knowledge in virtual project environment, and how is the process facilitated?***

To reply this question, five sub-questions were formulated, each embracing some parts of the problem. In this chapter the research strategy and design, along with the five research questions, are presented. It is explained how the methodological choices support replying the research questions. Then, the empirical setting is introduced, and finally the processes of data collection and analysis are reported.

3.1 Research strategy and design

This is a qualitative research consisting of two empirical parts. The first part, an in-depth case study, creates understanding of knowledge communication between dispersed experts during their knowledge co-creation process. Case study was chosen for research approach because it allows a researcher to retain the holistic and meaningful characteristics of events. The case study researcher typically asks questions in forms of “how” and “why”, and seeks to understand complex social phenomenon, which can be related, for example, to small group behaviour. (Yin 2009, 4)

Defining the unit of analysis, the case, in detail is important in order to distinguish data about the subject of the case study, i.e., the phenomenon, from data external to the case, i.e., the context (Yin 2009, 32). In this study, the unit of analysis is the knowledge co-creation process. Pettigrew (1997, 338) defines a process as “a sequence of individual and collective events, actions, and activities unfolding over time in context”, while adopting the meaning of process as “developmental event sequence” (Van de Ven’s 1992, 170). Time is crucial in temporary organizations as time horizons and time limits have implications for action in many ways (Lundin and Södermalm 1995, 438). Indeed, when a *‘project’* or a *‘process’* is studied, extra

attention should be paid on its context; the spatial and temporal aspects in general (Maaninen-Olsson & Müllern 2009), and the changes observed in the phenomena over time (Bidart et al. 2013; Pettigrew 1997).

Knowledge co-creation process, the phenomenon of interest in this thesis, is surrounded by important contextual factors related to virtual project environment, such as the co-creation group being temporary, interactions occurring mostly virtually, and the process being discontinuous in the sense that participants may contribute only some hours per week and partly at different times. Also, the co-creation actors are experts in their own knowledge areas, which partly differ from each other. I have paid attention to these factors when formulating the research questions in order to elicit knowledge of the process in this highly interesting context.

In order to study the **knowledge co-creation process**, which *consists of individual and collective communicative actions of sharing and integrating knowledge at certain stages*, the following research questions are formulated:

RQ1. How a fast knowledge co-creation process proceeds between dispersed experts?

RQ2. How experts use a digital project platform and other communication mediums to share and integrate knowledge during a short-term knowledge co-creation process?

RQ3. How boundary objects and artifacts shape and facilitate knowledge co-creation process of dispersed experts?

Knowledge co-creation process was studied by combining two data collection strategies. Firstly, having an access to the digital project platform on which experts and project leaders shared knowledge in different formats was crucial for studying the process. By examining all the posts from the beginning to the end of the project, I was able to conceptualize the process as a story (Bidart et al. 2013, 745). In addition to written comments and replies, also the most meaningful documents,

“documents-in-interaction” (Prior 2008), were analysed, and the embedded triangle figures were also placed on the story timeline (see the appendix 4). Secondly, all project participants, both project leaders and experts, were interviewed to hear their experiences. I applied the Gioia methodology to analyse the interview data. The study of Nag and Gioia (2012) shows an excellent example of doing a qualitative data analysis systematically and thoroughly to develop a process model. Similarly to Nag and Gioia (2012, 427) my analytic approach started rather inductively, but I also “cycled between data analysis and consultation with relevant literature”, especially during later phases of the analysis. I became to adopt or got inspiration from some existing concepts, while I created some by myself. When the analysis progressed, also my awareness of the existing literature grew. Nevertheless, throughout the whole analysing process I kept my mind open for anything unexpected to be revealed from the empirical data.

Design of qualitative case studies is rather emergent than preordained. The researcher gets more information and understanding about the case through data collection, often including direct observation and semi-structured interviews, and is expected to keep eyes open also for unanticipated factors and focus the study on the features that gradually appear to be significant in the case. (Mabry 2008, 216, 218) The significant role of project leaders as knowledge co-creation facilitators, as well as the support needed in the context of virtual project environment, became known during the early phases of analysing the case data. As the aim was to create a holistic understanding of the knowledge co-creation process, which includes considering the contextual factors, it was decided that more empirical data and understanding of the facilitative actions of project leaders and the contextual support is needed. Therefore, the original research problem was modified, and the following two research questions were added:

RQ4. How project leaders act to facilitate the knowledge co-creation process?

RQ5. What kind of support is needed in virtual project environment in order to implement successful knowledge co-creation projects?

Hence, the case data was supplemented with four individual interviews and two focus group interviews of project leaders. These informants, different from the case informants, each has experience of operating in a leading role at least in one Solved project (all are conceptual design projects within the same virtual project environment, in which the company 'Solved' is the organizer or the "host"). Collecting and analysing the extended data enabled to understand the facilitative actions of project leaders in a greater detail, and to hear project leaders' thoughts and experiences regarding the support needed in the challenging context of virtual project environment. This "second" part of the empirical study was an important addition to filling the objective of a qualitative case study – describing the unit of analysis in depth and detail, holistically and *in context* (Patton 2002, 55).

3.2 Empirical setting

Next the setting for the empirical study is introduced. First, it is described how and why the particular setting was selected to study the phenomenon of interest in this thesis. Then the case, the involved actors, and the surrounding context are shortly presented.

3.2.1 Selection of the case and informants

A few key aspects were kept on mind when looking for suitable projects and groups for the empirical study. Although virtual communication and temporary working groups are interesting topics per se, studying any kind of a temporary virtual group would not necessarily enlighten the core interest of knowledge co-creation. Thus, the main "requirements", in addition to collaboration being mostly virtual and temporary, were related to task type and group composition. In the study proposal these features were formulized as: *"A group of experts can be a project team, an R&D team, or any other type of a team that has been formed to achieve a common goal that implies utilizing expertise of team members as well as acquiring, sharing and creating knowledge"*, and continued as; *"Team members can be employees of*

different organizational units or different organizations, or they can be hired freelancers".

For purposeful sampling, cases are selected because they offer useful manifestations of the phenomenon of interest, are information-rich and allow in-depth understanding (Patton 2002, 40, 46). Conceptual design projects of Solved provide an excellent opportunity to study knowledge co-creation between dispersed experts. Together with one of the Solved founders it was decided which one of the projects would be the most information-rich case for the study. In addition to the co-creation task, the group size, the project duration, and the use of the digital project platform made the chosen case purposefully selected. Instead of a working duo or trio, the case involved a group of experts, which was an important aspect to study group's interaction and communication of diverse knowledge. The project was on its midway when the study began. It was not a problem, actually quite the contrary, as we knew that there is a good amount of commenting on the project platform so it would be possible to study the process closely from the beginning to the end. All project participants, both project leaders and experts, accepted to be interviewed, which was important for the study.

In addition, four individual interviews and two focus groups were arranged after the significant and versatile role of project leaders had become known. The founder of Solved let us know the names of network members, each having experience of operating in a leading role in at least one Solved project before. Some had more experience than the others. From the two focus groups, the first one included the founders and other key persons of Solved. Each one of them has experience of operating in a leading role in the projects.

3.2.2 Description of the case and the context

"Solved is a cleantech advisory service and collaboration platform" (Solved 2016a). The aim of a Solved project is to solve a client's environmental challenge by creating a conceptual design as a collaborative effort between selected experts. The client can be, for example, a municipality, a nation or an industrial company, and the

client's representatives can actively participate in the co-creation with experts throughout the process. (Solved 2016a; Solved 2016b) One of the Solved projects is studied as a case in this research.

That being said, the case is a knowledge co-creation process of dispersed experts collaborating as a group for the first time. Their task of the group was to co-create an ambitious and multi-dimensional conceptual design for a Finnish city. The duration of the co-creation process was 12 weeks, from which the last couple of weeks were mostly used for finalizing work conducted by the two project leaders; Project lead and Content/Business lead (in Solved terminology). It was not a full-time work for anyone. Working hours per expert were closer to a couple of days than a couple of weeks. Solved projects typically require this type of a fast co-creation.

Most of the Solved projects, so far, have been sold to clients and partly or completely orchestrated by the company founders, but the plan is to turn the network of experts more self-organized. In this case, project leaders were the contact persons towards the client, and orchestrated the process. A Solved founder participated in the process as an "additional" expert and also helped project leaders at both setting up the project and finalizing it. Another Solved founder was on the project's platform site but did not participate in the process.

In addition to project leaders and the Solved founder(s), the co-creation group consisted of six experts. Table 2 summarizes the existing relationships between group members and their previous experiences of Solved projects. Some of the group members had previously worked together in a Solved project, and therefore knew each other at some level beforehand. The closest relationship was between the Project lead and the Content/Business lead who are colleagues and co-founders of a circular economy consultancy company. Also one of the experts had previously worked together with the Content/Business lead, so they also knew each other quite well. Three group members had no previous experience of working in a Solved project, whereas two had experience of several projects. Project leaders had not run a Solved project before. The co-creation group was rather heterogeneous in terms of age, gender, and diversity in expertise. There was also a bit of cultural diversity since one expert was from Holland, one originally from Ireland (nowadays living in Finland), and the rest were from different parts of Finland. All project

participants are members of the Solved network of cleantech experts and therefore likely to possess knowledge related to cleantech topics. However, cleantech was not the main expertise of each participant, and also the cleantech industry itself is a rather broad knowledge field containing many different areas of specialties.

Table 2 Co-creation group members and their connections

Co-creation group members	Previous experience of Solved projects	Knowing the other participants beforehand
Project lead female	**No** (Planned but no realized projects)	**Yes, some** (Colleagues and co-founders with Content lead)
Content lead (+Business lead) female	**Yes** (As a "hangaround expert")	**Yes** (Everyone at some level, except "Hangaround expert")
Expert 1 male	**No**	**Yes, one** (A former colleague of Content lead)
Expert 2 male	**Yes** (one)	**Yes, one** (No shared working experience, but knew Content lead and some of the others "as names")
Expert 3 male	**Yes** (one)	**Yes, some** (Content lead, through a previous Solved project, and has also met Project lead)
Expert 4 male	**Yes** (several)	**No** (No shared working experience, but knew some participants "as names")
Expert 5 female	**Yes** (several)	**Yes, one** (Content lead, through a previous Solved project)
Expert 6 "hangaround" male	**No**	**No**
+ Founders/ additional experts (male)		
	Note: "Hangaround expert" = Used to mean a person participating in the project voluntarily without getting paid (usually for the first time for learning purposes).	

The group's communication was mostly technology-mediated. The group utilized the digital project platform of Solved for posting ideas and links, commenting posts of others, and sharing documents. They also had frequently audio/video calls but the whole group was never participating at the same time. Project leaders met each other face-to-face on a regular basis. They also met face-to-face with one of the experts twice.

The representatives of the client participated in the group's kick-off meeting by being physically at the same place with project leaders (experts joined the meeting virtually). During the co-creation process project leaders met a couple of times with the representatives of the client, who gave feedback and/or an approval to the ideas and emerging conceptual design of the moment. Two representatives of the client had an access to the platform but they did not participate in discussion. Project leaders had a role in transferring knowledge between the experts and the client representatives.

The final conceptual design solution was visually presented by the group as a three-level pyramid consisting of 11 elements (see the last figure in appendix 4), and each element was explained in a presentation and a report. With the exception of some time management challenges (final versions of the presentation and report were delivered after the deadline, and many participants said that they used in the project more hours than what was initially agreed to), the project was rather successful. Project leaders praised the group and the final outcome, i.e., the conceptual design solution, on the platform during the weeks 11 and 12, and also said that the client was very pleased with the work. Experts, on behalf, said in the interviews many positive comments about the group, project leaders and the project in general (the project's final outcome was not ready at the time of the interviews, so there were no comments regarding that). An overall opinion about the project seemed to be very positive.

3.3 Data collection

The empirical research data is presented in this chapter (table 3). The case data includes textual data collected from the project platform, observational notes from three conference calls, as well as semi-structured interviews of all group members, both project leaders and experts. Facilitative actions of project leaders, and support needed in virtual project environment, were studied through individual and focus group interviews. All of the interviews were taped, and later transcribed (by an official third party). The purpose of the research was told to informants beforehand, and the permission for recording of an interview was asked in the beginning of each interview. All interviews were held virtually, either through a Skype call, or a Google hangouts call. In some interviews the video option was turned off, or kept off, in order to improve the sound quality. The thesis' supervisor, Kirsimarja Blomqvist, attended some of the interviews, and in those interviews, she also asked questions applying the interview guide.

Table 3 The empirical data collection

	METHOD OF DATA COLLECTION	DATA	PURPOSE	EVIDENCE TO ANSWER RESEARCH QUESTIONS
	Interviews of Solved founders/ key personnel	3 interviews (à 34 - 50 min)	Receiving background knowledge helping to form meaningful interview questions.	
CASE DATA	**Platform discussions** *Case data - Textual*	Total 178 posts and comments, 58 documents	Collecting detailed, factual information of the knowledge co-creation process from its complete duration. Collecting information of the artifacts in use (documents-in-interaction). Understanding the nature of asynchronous discussions.	RQ1 RQ3 (supporting RQ2)
CASE DATA	**Virtual group meetings** *Case data - Observational*	Notes from three audio/video calls (à 1,5 - 2 h)	Complementing the understanding of the knowledge co-creation process. Understanding the nature of synchronous discussions.	
CASE DATA	**Semi-structured interviews** *Case-data - Oral*	8 interviews (à 25 - 44 min)	Getting information about co-creation actions that took place outside the platform, as well as understanding the reasons behind actions (complementing the understanding of the knowledge co-creation process). Understanding participants' (both project leaders and experts) experiences regarding different aspects of the knowledge co-creation process, including facilitative actions of project leaders, and factors impeding experts' participation.	RQ1 RQ2 (supporting RQ3) (supporting RQ4)
EXTENDED DATA	**Individual interviews** *Other people having experience of leading Solved projects*	4 interviews (à 34 - 50 min)	Collecting data regarding project leaders' roles, (facilitative) actions and experiences regarding knowledge co-creation process.	RQ4 RQ5
EXTENDED DATA	**Focus groups** *Other people having experience of leading Solved projects*	1st focus group: 5* participants, total 89 min 2nd focus group: 3 participants, total 98 min *2 partcipants not able to join all the time due to connection problems, 1 participant had to leave after 60min	Collecting data regarding project leaders' roles, (facilitative) actions and experiences regarding knowledge co-creation process. Collecting project leaders' ideas for improvements, and opinions regarding the needed support in virtual project environment.	RQ4 RQ5

Semi-structured interview, at the heart of qualitative research, can give both retrospective and real-time accounts by the people experiencing the phenomenon of interest (Gioia et al. 2013, 19). Interviews of project members were conducted during the weeks 9 and 10, and one interview on week 11. Overall duration of the project was 12 weeks. In alignment with Gioia et al. (2013, 19-20) the research questions were well thought out beforehand, but kept at a quite general level not to lead respondents. Flexibility was preserved to act according to interview situation, so some questions were slightly modified and additional questions asked based on informant responses. Interviews were used to collect data of things that cannot be observed, such as feelings and thoughts, perspectives of different parties, as well as situations in which the observer was not present (Patton 2002, 341).

In addition to interviews, there was an opportunity to collect data from a digital project platform. Platform posts provided genuine (situation not created by a researcher) and time-accurate information regarding events and actions occurring during the knowledge co-creation process. This enabled to form a general understanding of the whole process and place the process events on a timeline (appendix 4). Platform data and interview data complemented each other, and together formed the empirical evidence to answer research questions concerning the knowledge co-creation process. In some questions platform data was primary and interview data complementary, and vice versa. Interviews gave information about communication and knowledge sharing occurring outside the platform, whereas the virtual project platform, especially the shared documents, gave information regarding the objects and artifacts. Interviews were insightful in terms of giving understanding of reasons behind acting or not acting (e.g., why an expert did not comment anything on the platform in a certain period). Interview data also strengthened some perceptions made based on the platform discussions (e.g., a rather laborious job of project leaders).

Focus groups and individual interviews can be used as complementary techniques to strengthen the total research project (Morgan 1997, 23), as was done in this study. Advantages of individual interviews include having closer communication between an interviewer and an informant, and allowing more time for each informant to speak from a personal point of view, providing an in-depth understanding of a

person's opinions and experiences. However, sometimes if the matter of interest is more challenging to speak about, for example, habit-ridden or not thought out in detail, it requires considerable skill to get the informant to speak about the matter in detail, and in that case a group setting can lead to a more productive discussion. (Morgan 1997, 10-12) We wanted to conduct focus groups in addition to individual interviews as the synergistic effect of focus groups can lead to uncovered data or ideas when participants can build on responses of each other (Stewart et al. 2007, 43). We thought that in focus groups people might be able to collectively produce more detailed articulation about the essence of knowledge co-creation, which can be quite fuzzy, and also produce some practical ideas on which some future advices or best practices could be built on.

The ideal number of participants in a focus group are said to vary between four and ten participants (Liamputtong 2011, 43), or even between six and twelve participants (Stewart et al. 2007, 58). However, in this case a group size of three and five knowledgeable participants seemed to be quite good. The advantage of small groups is that participants can discuss in greater detail and more actively as a group so that everyone's opinion is heard (Liamputtong 2011, 42). The approach to interview questions and the moderator's role can be more structured, less structured, or a compromise approach (Morgan 1997, 39-41). The interview guide of focus groups (appendix 3) was planned to have enough structure to keep the discussion concentrated on the topics of interest but also loose enough to allow a lively discussion among participants. Research questions were arranged under six themes.

A PowerPoint presentation was created, and was shared with participants during the session, in order to increase participants' focus on the current theme, as well as to create a relaxed atmosphere to diminish possible tensions caused by the virtual media. To do this, the language on the slides was rather informal, and the theme slides were decorated with nature themed images. At the beginning, the focus group was described to be an informal research and development approach, in which participants can share personal insights and experiences, and feel free to add on others views, "just like in a good coffee table discussion".

Each of the six themes was introduced by a researcher, which was followed by a short moment of silence for thinking, after which participants discussed about it. In the first focus group, two participants were on the move and due to connection problems could not participate all the time. Despite of these unfortunate distractions, experiences, thoughts and ideas from all participants were heard. The second focus group was more successful in a sense that there was more flowing discussing between the participants, and less interruptions caused by connection problems.

3.4 Process of data analysis

Next, the process of data analysis is described. Two types of data, digital platform discussions and interviews, were analysed separately, but both of them also helped in interpreting the other. Data analysis is inductive in a sense of discovering patterns, themes and categories in the data (Patton 2002, 453). However, some connections with literature were noticed, for example similarities with Lee's (2007) concepts of compilation and structuring artifacts, which were considered and compared with the empirical findings already during the analysing process. The key findings of this thesis, the process model (figure 13) and the complementing matrix (table 6), although including concepts emerged in the data and being based on the inductive analysis, are constructed logically (abductively) by organizing data through a logical scheme that links parts together (Patton 2002, 476).

3.4.1 Virtual discussions

Firstly, I copied all the posts and comments, one by one, from the platform to an excel sheet, and added a column showing the period (week 1, week 2,… week 12). I decided the chronology to start after the group's virtual kick-off meeting. Before the kick-off meeting, there were a few comments on the platform from the period of around 1,5 weeks. These comments I placed on the first column, which I called "Before the kick-off meeting", followed by the second column called "The kick-off

meeting”. After making the chronology I created a new sheet, in which each row represented a single week. First I wrote down a description of every week’s happenings to one column, and on the next column I wrote a shorter interpretation of happenings. More precisely, I first simply wrote down what I was able to see in the posts, comments and in the shared documents, and described, e.g., what type of knowledge was shared by whom, who replied by saying what, and which kinds of documents were shared on the platform. Then, on the next column, I wrote what could be understood by examining the posts and the documents, but what was not necessarily said directly by the participants. This included, e.g., purposes of actions, decisions that were made, and challenges that were faced. On the third column I wrote notes from the conference calls I was able to join. There were notes from three conference calls, each from a different week. I incorporated understanding from the notes into the interpretation of weekly happenings. The date of posting a comment is not visible on the platform, only a date of posting a document can be seen. Documents were shared actively, so I was able to quite accurately separate weeks from each other, however, there were a few comments I could not be sure about. Nevertheless, creating the weekly timeline formed for me a good understanding of the progression of the process.

Due to interest towards boundary objects and artifacts, I looked at each document, which was shared on the platform. Most of the documents contained a sort of background knowledge or benchmarking type of knowledge, which I did not investigate in detail. Instead, my attention was focused on the PowerPoint slides, which were frequently shared during the project. Usually project leaders shared a draft, on which experts made their own contributions and shared those versions on the platform. Project leaders then integrated the different versions into one document, which was discussed in a virtual meeting. This was a common way to work in the project. On the slides I was particularly interested in a triangle figure, which was created on the second week, and kept evolving during the project.

After I had got more knowledge both from the literature and from the case in forms of interviews, I returned back to the timeline. Now I was able to analyse the purpose of the triangle figures in more detail. Data analysis followed the hermeneutic circle since the interview data helped in interpreting the platform discussions, particularly

the role of the triangle figures (specific kinds of artifacts) in the knowledge co-creation process. The holistic understanding of the whole process was created by bringing parts together and seeing whether they make sense. (Patton 2002, 497-498)

3.4.2 Interviews

Interviews of case participants were analysed applying the Gioia methodology, which is a systematic approach aiming to increase rigor in qualitative analysis (Gioia et al. 2013). After receiving the interview transcripts I read them through a few times and wrote short notes to myself describing some first thoughts about each interview in general. After this, I downloaded interviews into an nVivo project, which I had created to support systematic analysis of the interview data. I could have used also excel sheets for the same data analysis but we thought the system might help to better keep track of the thinking and analysing processes.

In nVivo, I went through each interview line by line, and underlined the phrases and sentences which were related to areas of interests of this study, e.g., gave information regarding knowledge co-creation process. I edited the interview documents by adding an illustration of the informant's comments next to each underlined part. I separated illustrative comments with another colour and quotation marks. Most of the interviews were held in Finnish, so it was at this point, when the selected comments in Finnish were translated into illustrative quotes in English. Illustrative quotes in those two interviews that were conducted in English, did not necessarily differ much, or at all, from the original comments of the informant. First-order concepts (Gioia et al. 2013), or "new nodes" in nVivo, were created based on the illustrative comments. Some illustrative comments were directly transferred to first-order concepts, while some comments were slightly modified or shortened, however retaining the informant-centric terms, as instructed by Gioia et al. (2013). I created a few supportive topics, a bit like headings, such as "Experts as individuals", "Co-creation at group level actions", and "Virtual working, platform", under which I placed the first-order concepts to keep the levels of analysis separate, and data

organized. Later these topics or headings were slightly changed, and some nodes were moved from one topic to another.

I had picked up around 100 first-order concepts from the interview transcripts when I started to further proceed with them. The easiest way for me was to print out the list of first-order concepts, and to underline with the same colour those first-order concepts that seemed to represent similar ideas. Then I started to consider what could be a label, or a theoretical term if I already had one on mind, which best describes the set of similar first-order concepts. After I had some initial second-order concepts or themes thought out on paper, I made the modifications in the nVivo project to again see the clear, visual hierarchy of concepts. I continuously reminded myself to consider *"What's going on here"* when thinking about the multiple levels of codes and themes (Gioia et al. 2013, 20) and *"What are the core things, the most important aspects that I need to understand about knowledge co-creation process".* I found out that a few first-order concepts, e.g., related to trust and motivation, stayed quite discrete, and did not really enlighten the core interest of the study. Although extremely important antecedents of collaboration and collective knowledge creation, I decided to exclude these first-order concepts from the systematic analysis, as I felt they did not directly describe what *actually happens* during the knowledge co-creation process[1]. These comments were still valuable as I was able to conclude on my mind that there was motivation and excitement towards the project, as well as some level of trust, and on that sense, there was a good premise for knowledge co-creation in the project.

Interviews of project leaders (both the individual interviews and focus groups) were analysed similarly to case interviews. However, now the main research interest was shifted from the detailed focus on knowledge co-creation process to aspects of facilitation; both facilitation during the knowledge co-creation process (actions of project leaders), and support needed from the surrounding context (virtual project environment, i.e., Solved)[2]. The number of first-order concepts was first 186, but was gradually diminished to under a half, as very similar first-order concepts were

[1] The final data structures of these interviews can be seen in appendices 5 and 6, and the interview guide in appendix 1.
[2] The final data structures of these interviews can be seen in appendices 7 and 8, the interview guide of individual interviews in appendix 2 and the interview guide of focus groups in appendix 3.

merged into one. Coding was done under three headlines to keep the data organized; “Facilitative actions of project leaders”, “Need for facilitation during the process” and “Support in virtual project environment”.

4 FINDINGS

The results of the empirical data analysis are presented in this chapter. Quotes from the interviews and platform discussions are in italics. Existing literature is referred to only when a specific concept presented by another author is applied in the data analysis. Key empirical findings alongside previous research are presented in chapter 5 (Discussion).

4.1 Knowledge co-creation process

The case was a knowledge co-creation process in which a group of experts collaborated for a short period of time for creating a novel and multidimensional conceptual design of circular economy solutions. The duration of the co-creation process was 12 weeks, from which the last few weeks were more or less finalizing work done by the project leaders. Although the project spanned nearly three months, hours used by each expert during the project were close to a couple of days.

Due to limited amount of time and a relatively small project budget, and due to geographical distances between group members, face-to-face meetings with the whole co-creation group were not arranged. So, co-creation activities and interaction took mostly place virtually through written discussions on the digital project platform and through oral discussions on conference calls. The conceptual design was built together by using a triangular artifact as a boundary object, which helped the dispersed experts to approach and progress with the multidimensional concept.

In the next sub-chapters the case findings are shown. First, the progression of the process and the identified two co-creation phases are presented. Then the roles of the digital project platform and synchronous discussions during the process are analysed. Finally, findings regarding the triangular artifacts are exposed.

4.1.1 Unbounded and solution-oriented phases of co-creation

Co-creation discussions and actions were often centralized around a visual triangular figure embedded in PowerPoint slides. The triangular figures presented in this chapter are copied with a project leaders' permission from the materials shared on the digital project platform during the process. These figures illustrate how knowledge, in practice, was collected and integrated at different co-creation phases, and how the conceptual design solution gradually was created. In chapter 4.1.4 the roles of the triangular artifacts are further analysed, but in this chapter they are shown to illustrate the progression of knowledge co-creation.

In the **unbounded phase of co-creation** (figure 3) knowledge communication is active and feels effortless, and "problem framing" (Schön 1988), the process of structuring and formulating the problem (Cross 2004), stays very open. The co-creation group knows the task, and knows the topic, but definitions are loose enough for all kinds of ideas and pieces of knowledge at this point. The purpose is to collect diverse ideas and knowledge from different sources to build a shared and rich knowledge basis between dispersed experts co-creating a solution.

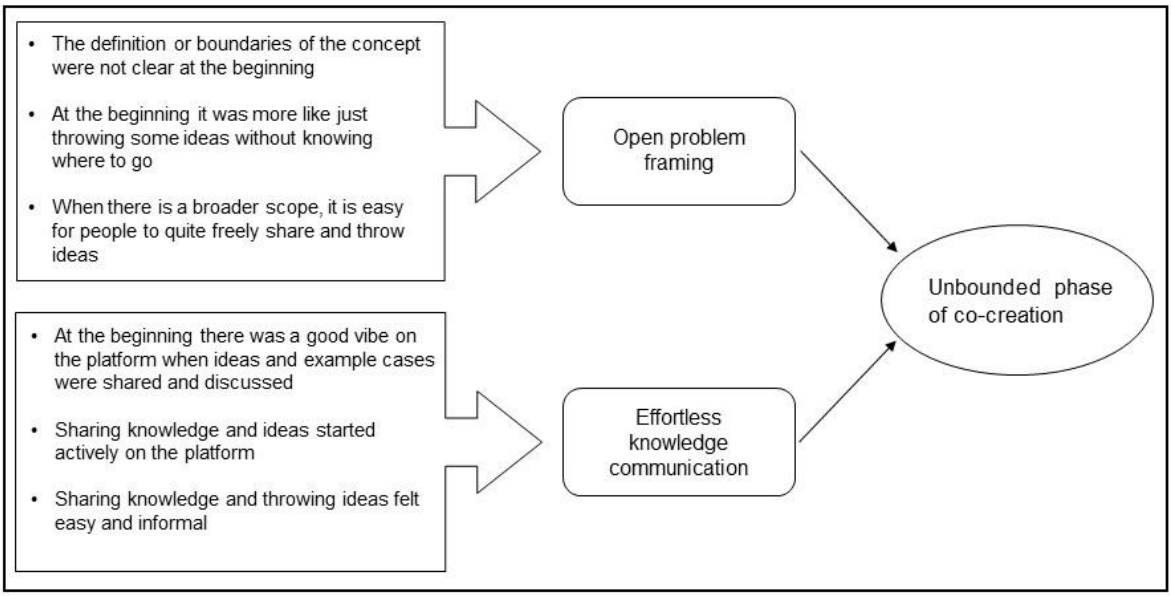

Figure 3 The aggregate dimension "Unbounded phase of co-creation"

Below is a platform comment from one of the two project leaders from week 1. This comment is a reply to comments of two experts who already started to discuss how to define the concept and what, on their opinion, should be a part of the project outcome.

"…We need to start with a lot of different perspectives and ideas and then start grouping the ideas under different themes. Prioritization comes later when we have better understanding of the key "criteria" for the prioritization."

By saying this, the project leader asks experts not yet to set boundaries, or start choosing things and considering relations, which are actions of framing a design situation (Schön 1988, 182). Instead, she wants the group members to continue brainstorming, i.e., to share diverse knowledge and ideas without any restrictions, and thus to stay in the unbounded phase of co-creation for a little while.

Over half of all posts on the platform were published during the first four weeks. More specifically, 90 posts were published in weeks 1 – 4, whereas 80 posts were published in weeks 5 – 12. This describes, not only how the platform better supports the early ideation phase than the later phase of focused co-creation, but also the nature of the co-creation in general – sharing ideas and knowledge at the beginning is effortless, which is reflected in the quantity.

Open problem framing enables effortless knowledge communication (figure 4) because, when there are no boundaries limiting what to share, an individual can share basically anything without worrying how well it fits the context and goes together with the elements others have already shared. The unbounded phase of co-creation is rather individual-centric in a sense that it allows one to share rather freely the knowledge one already possesses or has an easy access to, and considers interesting to be shared. At the beginning of the project the platform was actively used for knowledge sharing and ideation. Project leader's comment below describes how open problem framing enables effortless knowledge communication on the platform at the beginning of the project.

"…everyone can quite freely then search from own files, all kinds of examples what they know, and stuff. When there is a broader scope it is easier to throw there."

At the beginning of the project, experts actively wrote ideas, shared documents and posted links to websites, as well as commented posts of others on the platform. Experts themselves described this phase of communication and knowledge sharing as easy, informal, open and active.

"I think the idea generation, throwing ideas out there is very easy. And really good."

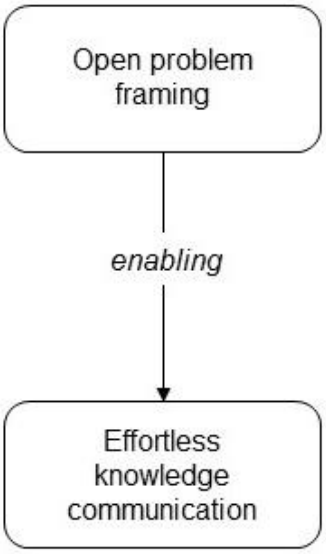

Figure 4 Open problem framing enabling effortless knowledge communication

In week two a "triangle model" was suggested as an approach for concept development. It was a three-level triangle shape with some headings and loose instructions regarding what each level should be about. The idea of presenting the concept elements in a triangular format was decided in the face-to-face brainstorming session between project leaders and one expert, and after that Content lead shared the idea with the group on the platform:

"…how to select the crucial elements out of a plethora of different things. We decided to suggest a triangle model for the structure (we've used it in one of our client projects to bring clarity to sustainability focus areas & actions)."

Next each participant was asked to fill in the empty triangular framework with own ideas. Figure 5 shows the three-level triangular figure and the following empty triangular figure, which project leaders used to collect everyone's ideas. Although

the framework gave a structure for ideas, the instructions around it were so loose that it kept the problem framing rather open.

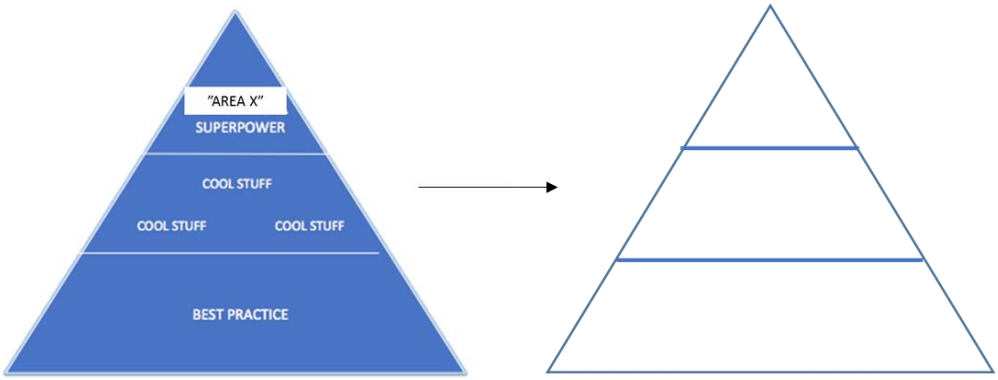

Figure 5 Triangular artifacts at the unbounded phase of co-creation

Even though knowledge communication was active on the platform during the first weeks, not everyone participated in it. One expert said the reason was the rush caused by other obligations at the same time. However, perhaps open problem framing, although being an enabling factor for effortless knowledge communication, may also impede knowledge communication of individuals who do not feel comfortable with the situation's 'openness'. Interview comments of a couple of informants revealed some feelings of hesitation, feelings that may have been barriers to communicating knowledge effortlessly at the unbounded phase of co-creation.

"But the beginning is always quite intriguing when not knowing own place in it, whether I am needed in this project, and if yes, then in what way."

One expert mentioned about the importance of feeling ownership towards the project. The feeling of ownership was linked to a clearer understanding of the situation as a whole and meaningfulness of own actions.

"Maybe there first need to be understanding of what to do, in which phase, and where does it lead, to know the beginning and the end, and perhaps also be recognized as a contributor..."

When diverse ideas, references and other sources of knowledge have accumulated on the platform, some decisions need to be made. Choosing among the ideas and deciding a shared focus for the actual co-creation phase starts the **solution-oriented co-creation** (figure 6) in which knowledge is both individually and collectively processed by keeping tightly on mind the project objectives and the desired final outcome, i.e., the solution.

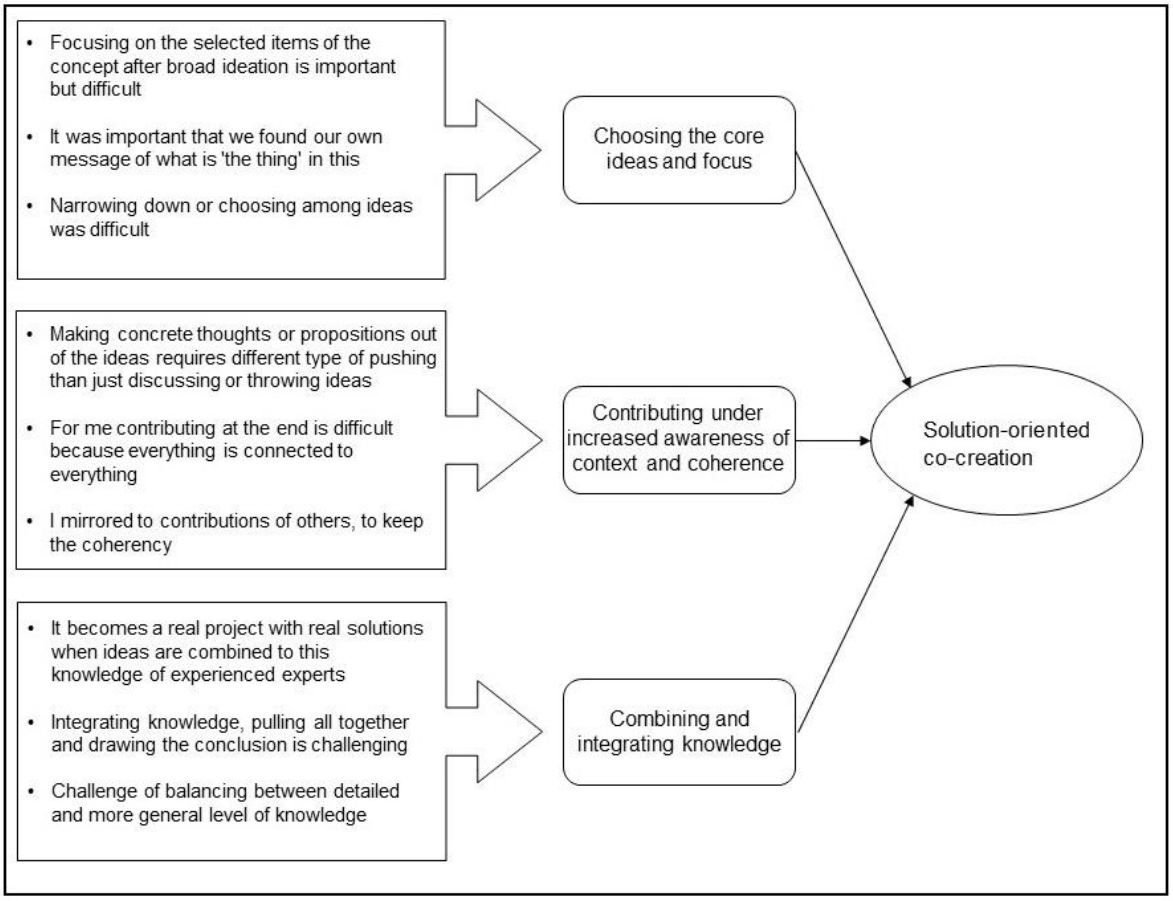

Figure 6 The aggregate dimension “Solution-oriented co-creation”

Starting and staying tightly on the solution-oriented co-creation, instead of open ideation, is extremely important especially in a short-term project like this. However, it can be challenging as described by one expert:

“But I think it's quite difficult, when you have to make ten ideas down to three or one or two. I think we found it difficult to really say, now we have a little bit of time left,

let's focus on expanding and adding detail to our chosen few ideas. And let's not always be generating new ones."

In practice, the transition from the unbounded phase of co-creation to the solution-oriented co-creation does not happen at once. However, forming a triangular artifact with concept elements (figure 7) can be considered as a clear step towards a growing solution-orientation. This triangular figure was one slide in a PowerPoint presentation which project leaders presented to the client in week 4, and received an acceptance to move forward with the ideas. Some of these 12 elements were changed later during the process, but nevertheless this triangle gave a focus for the group from the week four onwards.

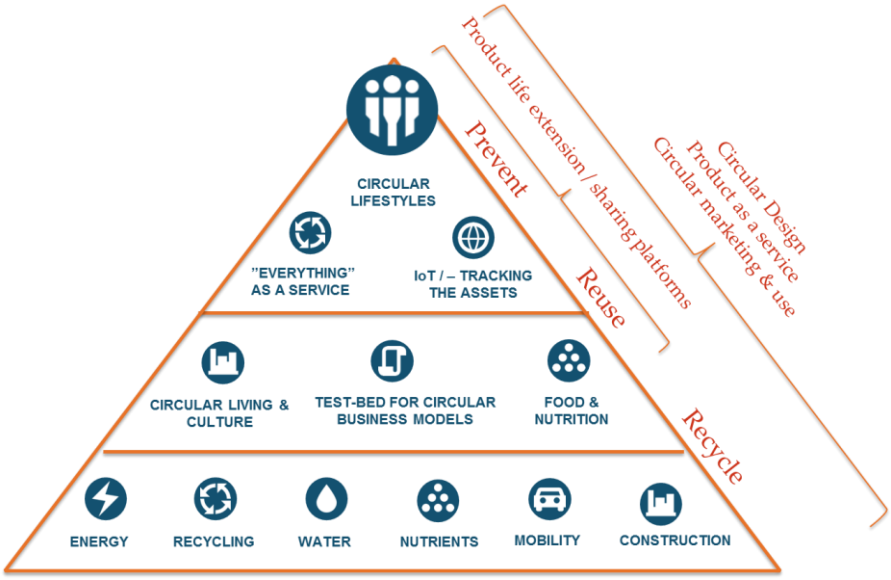

Figure 7 Triangular artifact at the point of growing solution orientation

Once the solution orientation grew, also the awareness of context and coherence grew, allowing no longer effortless knowledge communication. Project leader describes below the difference between effortless knowledge communication and contributing as well as assessing contributions in the situation of increased requirements created by increased solution-orientation.

"...when needing an expert's self-produced content, or it modified or brought somehow forward is more challenging. So it is easy to get references, knowledge, links and all these kinds of things, but when producing own content, bringing that to

a right direction, and whether it is good enough, or whether something more is needed, is more challenging."

After choosing the core ideas and focus, the work was divided in order to utilize everyone's expertise efficiently and to anchor it more explicitly to the concept solution, and therefore each element, for example, "water" was delegated to one expert (figure 8).

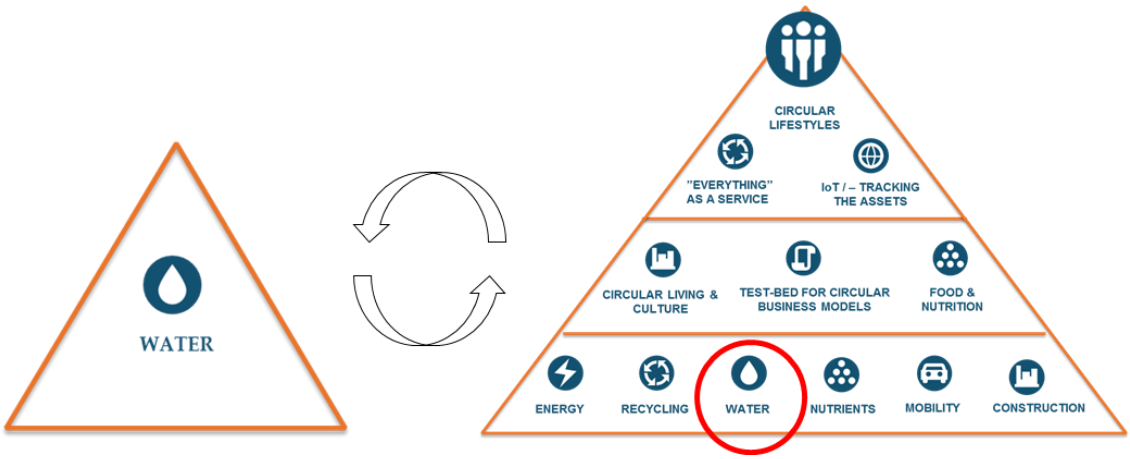

Figure 8 Triangular artifacts at the solution-oriented co-creation

Each expert had now a more concrete area of responsibility, from which to prepare a slide. The conceptual design solution was gradually developed so that project leaders combined the slides of experts to one presentation, which was discussed in the group conference call, after which new modifications were made individually. It was an iterative process (figure 9), which progressed through shifts between individuals' text-based contributions and group's oral discussions. It step by step refined and crystallized the emerging concept solution. The process of creating collective knowledge is more interdependent and iterative than sharing individual knowledge. It requires more effort and time, and thus may feel like a repetition, as described by one expert:

"I found that we repeated ourselves, and not really made as much progress over the last couple of weeks than we maybe originally did."

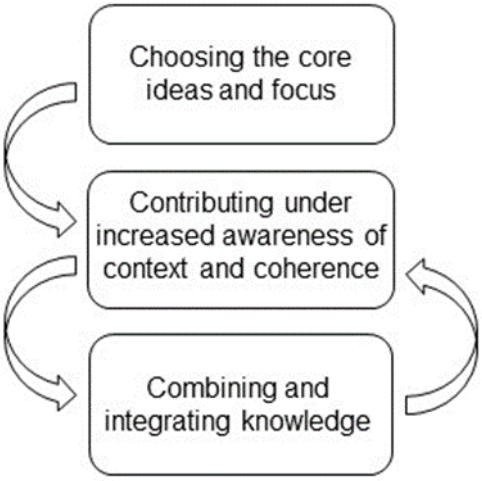

Figure 9 Iterative process between contributing and integrating knowledge

4.1.2 Virtual project platform and asynchronous discussions

The digital project platform of Solved enabled connecting experts despite of their physical locations, set up the project, and thus it provided a means for the co-creation in the first place. The project platform provided **basic sociomaterial support for co-creation** (figure 10) by being the major 'project scene' where each expert was able to return and contribute at any time. It shaped and helped knowledge communication, especially at the beginning of the co-creation. Most of the participants felt it was easy to throw all kinds of ideas and knowledge on the platform. Compared to sending emails, sharing ideas and knowledge on the platform was seen as much easier and more constructive for co-creation, as one expert describes:

"I suppose the idea of just posting things to a project, and not to an individual person, is probably much more constructive for design and for thinking. And for innovation. You don't feel like you're bothering someone by filling up their inbox. So it's very much a FYI, here's some information."

The platform, as a medium for primarily asynchronous communication, has its pros and cons. As a positive side, it allows an individual to participate when he or she prefers, making it easier for each expert to organize schedules and contribute on

the exact moment of having ideas on mind. On the other hand, the platform was considered as a medium of greater uncertainty, as one does not know when the message will be read and reacted by others. The cyclical rhythm of discussing and occasional delays of even days were considered normal.

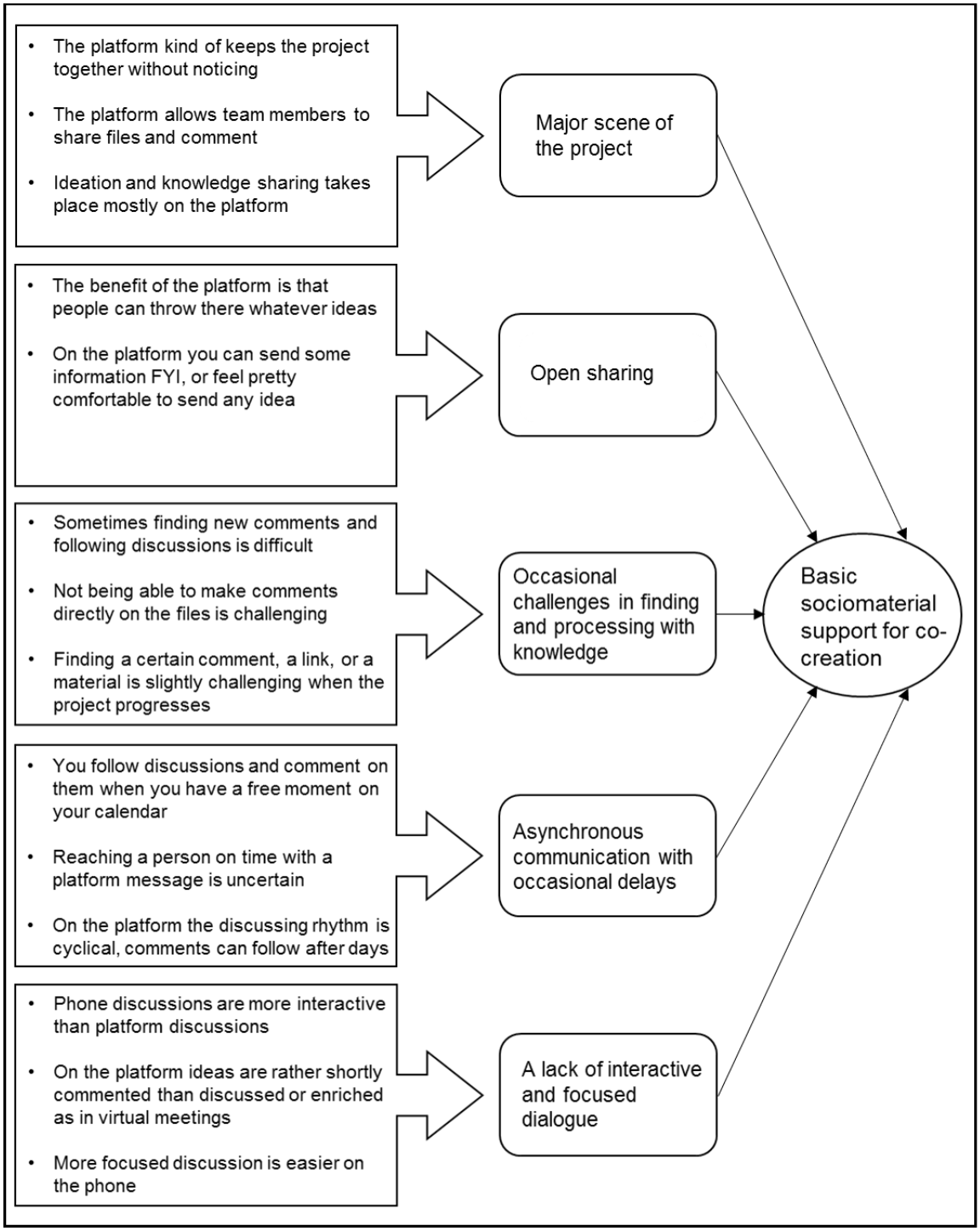

Figure 10 The aggregate dimension “Basic sociomaterial support for co-creation”

Finding certain comments or documents was sometimes challenging, especially when the project progressed. Participants also felt it was challenging not to be able to edit documents on the platform. This also created extra work for project leaders, who handled the different document versions, provided new templates and integrated modified documents.

In addition to, and as a result of the above mentioned aspects, the platform discussions were seen to lack interactivity and focus. Therefore, synchronous oral discussions played an important role in co-creation. Some respondents wished the platform would be easier to use on mobile to have an easier and faster access to the project, to better support fast reacting and making the discussion environment more dialogic.

4.1.3 Synchronous discussions

In addition to platform posts and occasional email messages, there were diverse synchronous discussions, which had an important role in the knowledge co-creation process (figure 11). These included group discussions, one-to-one discussions, and discussions in mini-groups of 3-4 individuals. Most of these discussions were virtual phone or conference calls, but there were also a few face-to-face meetings.

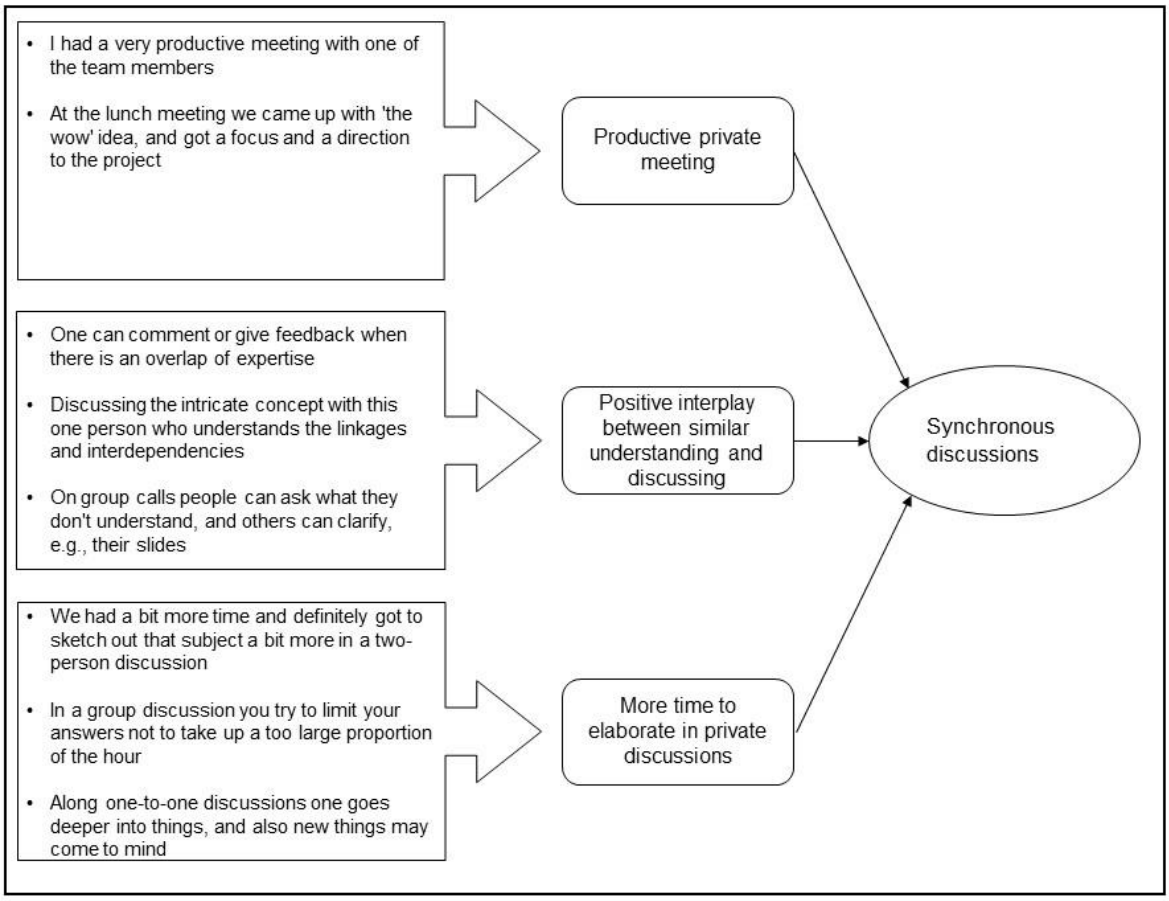

Figure 11 The aggregate dimension “Synchronous discussions”

The importance of synchronous discussions, and the positive interplay between similar understanding and discussing, both feeding the other, became clear in the data analysis. Firstly, synchronous group discussions facilitated a shared understanding. In group meetings people were able to ask in case they did not understand something, and others were able to clarify, for example the slides they had made. Regular group meetings were scheduled at the beginning of the project but it was challenging to agree times that would fit for everyone. That is why some of the scheduled group meetings were actually mini-group discussions rather than discussions with the whole group. This caused occasional challenges in communication and shared understanding.

“…the only example I've seen of people maybe not fully communicating or being understood is maybe if somebody had missed a meeting or two…”

Secondly, an overlap of expertise or similar understanding between some experts triggered them to discuss with each other. One wanted to get feedback and support from the person who knew and understood that specific matter.

"We were able to support each other or say 'that makes a lot of sense'. I actually think it was quite good to have the experts but also have this overlap… Then you have someone at least to give your ideas some foundation or some feedback. I found it quite good."

In private "additional" (not scheduled at the beginning of the project) discussions, held between two people or in a mini-group, there was more time for elaboration. In private discussions people were able to focus on one topic and go deeper into it, unlike in group discussions in which the time needed to be shared between all participants and all topics.

Almost all discussions were technology-mediated, except discussions between project leaders, who are also colleagues outside the project. An exception was an informal lunch-meeting between one expert and project leaders. This was described to be a productive meeting, which resulted in an idea of three concepts that together formed the idea of the whole concept. The first version of the triangular artifact was also created then.

"…we just went to have lunch, and there we just then drew on paper and considered what could be our wow-thing in this. It was like that, from that we got the direction and actually the focus for the whole work of ours."

When the process shifts from unbounded phase to solution-oriented co-creation, knowledge contributing is no longer individual-centric but the requirements for context and coherence increase. When knowledge processing turns to more collective and interdependent, participants feel oral discussions important or even necessary in order to have a shared understanding of the emerging knowledge solution.

"It is challenging to bring the content to a right direction, and to evaluate whether it is good enough or whether something more is needed. Then it feels like it would be nice to meet and discuss and go it through, for some reason."

4.1.4 Dual status of the conceptual design artifact

Developing the conceptual design solution occurred predominantly around PowerPoint slides, and more specifically around a triangular artifact. The triangular figure was usually embedded in PowerPoint slides and transported between project participants, first each making their own suggestions and contributions on it, and then these versions integrated into one document to be further discussed in a group meeting. The first version of the triangular artifact was developed in the face-to-face 'brainstorming session' between one expert and project leaders in week 2. PowerPoint slides and the embedded triangular figure played a great role in the co-creation process ever since.

"…made a draft presentation. And that was basically a PowerPoint presentation that they posted. And that's what we then, each of us made comments on that presentation… And they then integrated that into a new version. Then in the Google Hangout we discussed the new version with lots of comments verbally in the meeting. They made a new presentation etcetera. That was the way that we worked."

In general, the triangular framework helped the group to approach, and to progress with, the multidimensional concept.

"…it gave us as a team a way to structure all the different ideas that we had mentioned. So the most general idea was put at the top and then one level below that a few ideas that were a bit more worked out. And then concrete project ideas were positioned at the bottom."

Examining the actions around the evolving triangular artifact and considering the comments from the project members' interviews (Note: The interviewer did not directly ask about the triangle shape, instead several informants mentioned it while replying to other questions) uncovers the its nature, which is close to descriptions of both 'compilation artifacts' and 'structuring artifacts', two types of 'boundary negotiating artifacts' suggested by Lee (2007). Lacking standardized processes and objects for collaboration (Lee 2007, 314), participants created these triangular

artifacts, which helped them to share ideas, create shared understanding about specific design problems, transmit information, and divide labor (ibid 2007, 333).

The PowerPoint slides and the embedded triangle shape had clearly two functions, compiling and structuring, which occurred sequentially but also simultaneously, depending on the perspective. Therefore, the evolving triangular artifact is better described by its dual status than by dividing it into two different types of an artifact. This is not opposite to Lee (2007), who stated that artifacts are defined by their use so the status of an artifact can change over time when the context of use changes, and sometimes an artifact can be simultaneously physically incorporated or transformed into another artifact. (ibid 2007, 318, 333, 334)

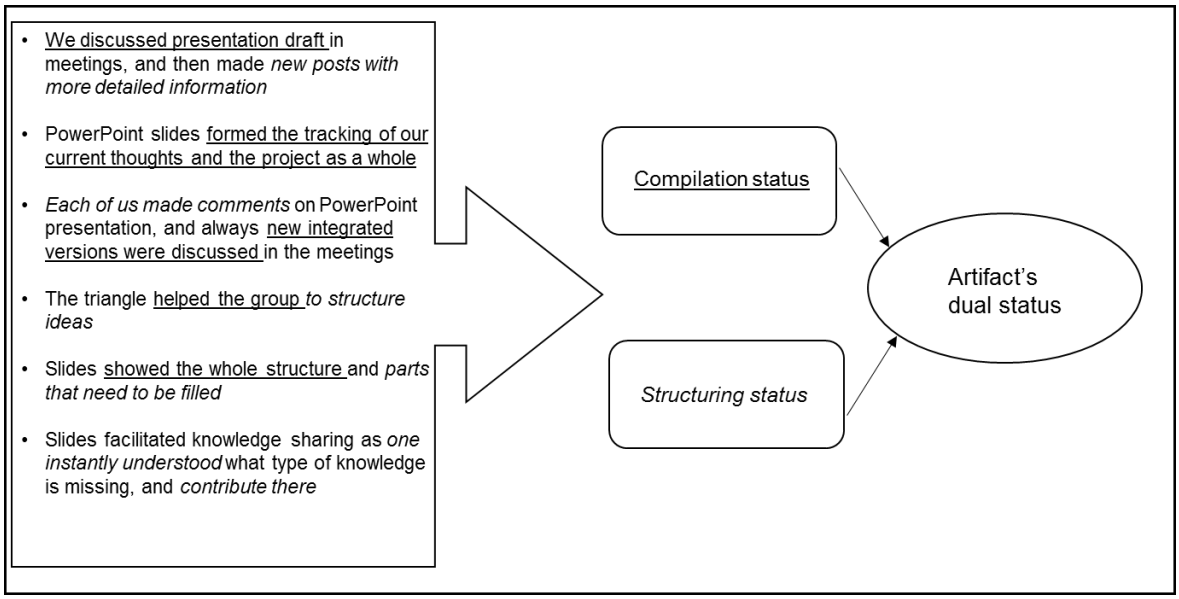

Figure 12 The aggregate dimension "Artifact's dual status"

The dual status of the artifact was analyzed through interview comments (figure 12) and through the timeline created from the platform discussions (appendix 4). Also knowing the close concepts from Lee (2007) helped to analyze the features of the artifacts in more detail. The compilation status, as the name suggests, compiles different ideas or concept elements together. Usually this was done by project leaders when they integrated separate contributions of experts into one triangle or presentation. Similarly to the description of 'compilation artifacts' (Lee 2007, 323) the compilation status was the artifact's primary status always when the artifact was

used to bring experts together to develop a shared and mutually agreeable understanding of a problem and to pass crucial information from one another. In practice, this process of alignment and sharing of knowledge occurred primarily in the virtual group meetings, in which the group members discussed about the integrated version of the concept. The focus then was on the concept solution as a whole.

Also structuring status helped to form a shared understanding but at the centre of thoughts and actions then was to move from the whole concept into its parts. Structuring status was most clearly separate from compilation status when the artifact was used to “direct and coordinate the activity of others” (Lee 2007, 325), i.e., when the concept elements were divided to experts as tasks to do. However, as the triangle itself is a structure, the structuring status of the artifact stayed as a secondary status also when the primary function of the artifact was to compile. Similarly to concept maps triangular artifacts gave a hierarchical structure for early ideas and for later concept elements. Although the descriptions of ‘compilation artifacts’ and ‘structuring artifacts’ (Lee 2007) quite well match with the dual status of the triangular artifacts identified in this case, there are significant differences between the studies related to both the co-creation group and the task, and therefore a ***‘conceptual design artifact’*** is, in this case, a more describing label for the evolving triangular artifact compared to the Lee’s concept of ‘boundary negotiating artifact’.

4.2 Facilitation of knowledge co-creation in virtual project environment

The results of knowledge co-creation facilitation are presented next. First, the case findings of participation of experts, particularly the factors impeding it (needs for facilitation), and actions of project leaders are presented. Further findings (considering the extended data, the “second” part of the empirical study) of facilitative actions of project leaders, as well as support needed in the virtual project environment are presented in sub-chapter 4.2.2.

4.2.1 Case findings of facilitation

By analysing the case interviews regarding the roles of experts and project leaders (data structure appendix 6), I found three main factors that slightly impeded some of the experts' participation, and three main ways in which project leaders facilitated experts' participation, in addition to taking general responsibility of the project.

The role and responsibility of each expert was to share knowledge from the own area of expertise and participate in co-creation. Thus, their main co-creation role was to be "knowledgeable agents". Naturally, experts are individuals with their own characteristics, competences and life situations affecting their participation. Ordering the specific first-order categories resulted in three factors, which slightly impeded some experts' participation; 1) Not seeing or knowing one another, 2) Waiting for clearer instructions, and, 3) Difficulties in following or understanding the discussions or materials. Rewording the impeding factors transformed them into needs for facilitation (table 4).

Project leaders had a significant and versatile role, including taking responsibility of general project management, responding to the client, and making the final decisions and integrating knowledge into the final presentation and report. Also they acted as knowledge co-creation facilitators, taking care of participation of experts. Thus, their co-creation role was to be responsibility takers and facilitators. Analysis of the interviews revealed three main facilitative actions of project leaders towards the experts (table 4).

Table 4 Needs for facilitation and facilitative actions

	Experts	**Project leaders**
Co-creation role	”Knowledgeable agents”	Responsibility takers and facilitators
Need for facilitation/ Facilitative actions	Need for seeing and/or knowing one another Need for clearer instructions Need for easier understanding and following	Encouraging and activating experts Collecting viewpoints of experts Communicating knowledge actively

Experts filled their duty as “knowledgeable agents” by sharing some of the knowledge they possessed already before the project, for example, by writing on the platform ideas that had been on their mind for a longer time. They also actively searched for ideas and knowledge, and shared, for example, local references from their home cities. Below a project leader describes how knowledge was received from the experts:

”Well, I think receiving knowledge was easy, sharing was very open in the project team, and everyone brought own competence, own thoughts. And these kinds of example cases, or knowledge from own earlier projects, or from other own work things.”

Most importantly, new knowledge was created from experts’ diverse and complementary knowledge through participation and interaction. Project leaders facilitated knowledge co-creation by encouraging and activating experts to discuss and participate also on the platform. They collected viewpoints from experts in a written form on the platform, through PowerPoint slides, and verbally in virtual group

meetings. Project leaders themselves showed a good example of communication and knowledge sharing by taking an active approach from the start. They also had an important task of transferring knowledge from the client to the experts because the client did not participate in discussion on the platform.

From the three impeding factors, the most frequently mentioned was the fact of not seeing or knowing the other project members. Despite of knowledge sharing being generally open and active, the fact of not knowing and not seeing people slightly impeded communication occasionally. One thing that might have affected this was that usually experts did not use the video option in virtual meetings, thus lacking nonverbal communication. There was a virtual kick-off meeting when the project started but it did not result in a feeling of knowing one another. It was also disturbed by technical distractions. Although experts understood that a face-to-face meeting with the whole group was not organized due to a small project budget, they would have liked to have one, as described below:

"It would be nice to have one, maybe it would deepen that interaction, and people would get to know each other, it is then easier to act on those meetings too."

"In that first kick-off everyone told only a short presentation, not more than that. Maybe there could have been a little more, maybe it still is little bit like who these guys really are. Everyone are still not known."

"Due to the fact that you do not meet in person but only through Skype or Google Hangouts, I did have trouble to remembering the faces and the names… I will forget probably who exactly is who and what they look like. So that remains difficult."

In virtual project environment feelings of ambiguity and uncertainty are not uncommon. On a small scale, these feelings were present also in the case project, despite of the fact that everyone agreed that project leaders did a good job in taking care of the project's progression and being actively in contact with the experts. There were occasional difficulties in following or understanding the discussions and the co-creation's progression. These difficulties were caused by 'dropping behind' after missing a meeting or two, by poor sound quality (and other technical problems), and by language differences. Many of the background materials were in Finnish, and the client wanted to have presentations and the final report also in Finnish,

whereas one expert did not know Finnish at all, and another one was a non-native speaker. Also the co-creation process itself, as described before, includes some level of openness, and is not as clear as some other types of projects. One expert said to rather wait for being contacted and given orders than ponder what to do because of the very scarce time resources.

Project leaders responded to the facilitation needs of experts by several actions. They facilitated individual group members in difficulties of following and understanding, and tried to keep everyone informed, by translating some of the Finnish materials to English, writing meeting memos, and discussing with individual experts also separately. In order to maximise effective participation of experts in such a short time, the needs could have been facilitated even further. Some of the needs are tied to contextual challenges, such as not being able to meet physically, and thereby they might have been beyond the reach of the project leaders. As facilitators of such a short-term knowledge co-creation process project leaders perhaps could have succeeded better in making the expectations and tasks even clearer, and plan the use of resources better in advance, to maximize the efficient participation of experts within the paid hours. Project leaders themselves also agreed with this, but in reality it is a challenging thing to do in a co-creation process, which starts with an unbounded phase of co-creation, and which nature is evolving and iterative rather than linear.

4.2.2 Extended findings of facilitation

Findings of this chapter are based on analysing four individual interviews and two focus groups of project leaders. These findings bring more breadth and depth to the earlier presented case findings of project leaders' facilitative actions, and extend the facilitation aspect to concern the contextual support needed in virtual project environment. Table 5 summarizes the extended findings of facilitation by showing the second-order themes (in italics) and aggregate dimensions (in bold) of the data structures (appendices 7 and 8).

Facilitative actions of project leaders include the actions project leaders told they had carried out, and the actions that they considered important (but which were not necessarily carried out). There were a lot of similarities in actions taken, and actions considered important to take, i.e., recognized needs for facilitation. For example, data analysis resulted in two similar second-order themes of knowledge structure; (1) Creating a framework to structure ideas (carried out action), and, 2) Adaptable knowledge structure (recognized need for facilitation), so these were merged into a singular theme. Sometimes it was difficult to interpret from the informants' wordings whether the action was carried out, partly carried out, or just considered important to carry out (in the next projects). For these reasons, I didn't separate these two categories when forming the aggregate dimensions from the first-order concepts and the second-order themes, and therefore "facilitative actions" include both the actions carried out and the actions considered important to carry out. Another category was formed regarding the support needed and wished from the virtual project environment, which **'Solved'** – as a virtual platform, as a network and community of experts, and as a host organization – is representing.

Table 5 Facilitative actions of project leaders and contextual support needed in virtual project environment

	PROJECT LEADERS	VIRTUAL PROJECT ENVIRONMENT
Time dimension	During the knowledge co-creation process	Beyond a single knowledge co-creation process
Facilitative actions / Contextual support	**Creating social conditions for co-creation** ○ *Face-to-face meeting* ○ *Knowing with whom one is working with* ○ *Creating a positive and compelling atmosphere* **Aligning emerging ideas with project objectives** ○ *Communicating expectations constantly* ○ *Appraising emerging ideas* **Supporting efficiency and effectiveness** ○ *Shared communication practices* ○ *Activating and guiding discussions* ○ *Taking care of focus and progress* ○ *Creating an adaptable knowledge structure*	**Social interaction within the network and local communities** ○ *Getting to know one another* ○ *Inter-project, peer-to-peer learning* **Procedural support** ○ *Supportive functionality of the platform* ○ *Clarity in working model and process* ○ *Administrational support* **Appropriate assessment of financial and knowledge resources** ○ *Knowing the competence of experts* ○ *Alignment of contributions and compensations with project objectives*

Project leaders can facilitate knowledge co-creation process by 1) Creating social conditions for co-creation, 2) Aligning emerging ideas with project objectives, and, 3) Supporting efficiency and effectiveness. Starting with the first category, project leaders had recognized that meeting physically with the project group, either occasionally or at least once at the beginning, facilitates virtual discussing. Knowing with whom one is working with, including knowing other person's responsibility areas, was recognized to be important for co-creation. These findings are supported by the experts' need for seeing and knowing one another (table 4). Creating a positive and compelling atmosphere resonates with the case finding of facilitative action of "encouraging and activating experts" (table 4). In addition to creating a generally positive atmosphere and excitement towards the project, the purpose of project leaders is to build a co-creation atmosphere in which all experts know that everyone's contribution is needed for achieving the shared goal. When there is only one person in the group having high-level expertise about a specific topic, such as energy solutions, it is vital to have this expert's contribution. Creating a little bit of social pressure, which is referred to by the word 'compelling', helps to keep experts active during the process despite of their other simultaneous engagements. After all, project leaders can lead experts in these types of co-creation projects only by encouraging and activating them:

"…they are anyway top experts. Then you just try 'hey could you please do this, it would be great if you could'. So, how you really lead people who do not do what you expected that belongs to their role, it still stayed a bit of a mystery how it could have been best handled."

Project leaders, being responsible for meeting the client's expectations, and often operating between the client and the group of experts, are in the position of aligning emerging ideas with project objectives. It is quite common that in co-creation projects objectives get crystallized along the process, and task priorities change. This requires from project leaders constant communication of expectations, and active appraising of emerging ideas in relation to the client's wishes. Experts' need for clearer instructions (table 4) can be responded by communicating expectations regularly, also at an individual level.

Experts are obligated to communicate and process knowledge in a relatively quick and organised way to reach the expected results in the given timeframe. Thus, project leaders need to support efficiency and effectiveness of co-creation activities throughout the process, increasingly towards the end. Analysing interview data revealed that knowledge sharing often occurs in ways that make processing the knowledge inefficient, and therefore shared communication practices would facilitate co-creation. Inefficient knowledge sharing behaviour includes sharing links to websites and posting long reports on the platform without writing the core idea of the shared knowledge, the reason for sharing it, or its relation to other knowledge. Creating a framework or a structure for knowledge was mentioned by project leaders both as an action already carried out in projects, and as an action which is planned to carry out in the next projects:

"...when you have there a hundred ideas, it is terribly difficult for anyone to anymore read or comment… sooner or later I have made segments so that 'here this is about four different things, and they go under these and these main headlines'."

"…in the next project I probably would create some framework right at the beginning. So that let's bring these things under these bigger categories, for example, what is related to the theme of sustainable development… To create some kinds of categories and start to seek ground rules through them... actually the headlines of the final document…"

Creating a knowledge framework, with some thematic headings and limited amount of space forcing people to write only enriched knowledge, is one way to support efficiency. However, one project leader pointed out that the structure should not be too strict, because along the process there might become some necessary changes. The multiple comments about the knowledge framework resonate with the case findings regarding the central role of the artifact with a dual status of structuring and compiling (figure 12). Both findings show the importance of arranging ideas and knowledge into a hierarchical structure while maintaining some adaptability.

In addition to shared communication practices and an adaptable knowledge structure, the category of "Supporting efficiency and effectiveness" include actions of activating and guiding discussions, as well as taking care of focus and progress.

In the case findings I presented the two phases of knowledge co-creation, and said that starting and staying tightly on the solution-oriented co-creation, instead of open ideation, is extremely important yet challenging. The findings of project leaders' facilitative actions strengthen the notion. There were many comments, including the ones below, describing how the ideation phase often extends too much (both in scope and time):

"And then towards the end of the project and, actually, getting the project to end, I have found it important to start focusing the discussion and the output. Quite often, if not in every case, it is some kind of document, but I have also learned that when there's an enthusiastic team, the discussion, and the ideation, is going to continue, if not forever, then at least very long…"

"It had to be stopped like 'not a link more, because we won't be able to wrap it up'. It would have continued indefinitely."

Moving from facilitative actions of project leaders to contextual support needed in virtual project environment, three main things were found; 1) Social interaction within the network and local communities, 2) Procedural support, and, 3) Appropriate assessment of financial and knowledge resources. Support, or a lack of it, regarding these three categories affect the knowledge co-creation process, and the impact goes beyond a single project. It is good to notice that Solved is not only a platform provider but an active participator in creating, and sometimes even carrying out, the projects. This is reflected on the expectations or wishes project leaders (and experts) have towards Solved.

The first category of contextual support considers social aspects, which virtual project environment often lacks. Particularly in large networks a personal connection and an opportunity for face-to-face meetings may be nonexistent. Despite of being a network, Solved has also features of a community (and a plan to have local communities). The interviewed project leaders did not think about the projects as one-time work arrangements. Instead, they were thinking about longer-term improvements, such as inter-project, peer-to-peer learning. One project leader suggested that there could be a face-to-face meeting once or a couple of times a year for having project presentations and for learning from each other. Another

project leader suggested to have a group or a spot on the platform to talk about projects and share best practices in a more frequent manner. Getting to know each other, in general terms, was considered an important thing, which would pass many problems.

The second category is procedural support, which contains both technological and organizational aspects. Project leaders were hoping to receive this type of support to facilitate project setting and running. The virtual platform, as it currently functions, was considered more as a discussion platform than as a co-creation platform and a project tool. Project leaders hoped the platform would allow them to allocate tasks, and that it would help to navigate through the process. Regarding knowledge processing, the wishes for functionalities included being able to edit documents on the platform, as well as to categorize and vote on ideas. More supportive functionalities of the platform would ease project leaders' actions of supporting process efficiency. Although they understood that co-creation projects can be distinctly different from each other, and that the nature of co-creation is iterative and includes a little bit of uncertainty, project leaders expressed a wish for clearer working model and process. Also they hoped to have some clarity between different leading roles as there are usually two or three leaders with different titles in one project. Each has an own key responsibility but in practice the roles and responsibilities often overlap, and, without clear communication, it causes confusion. Project leaders also wished for receiving administrational support, like receiving common document templates, guidelines, and being able to follow working hours to know the resources situation.

Finally, support in evaluating and aligning the financial and knowledge resources with project objectives is needed in virtual project environment. The challenge of an appropriate assessment of resources occurs when the group needs to be formed, as well as contributions and compensations agreed, for each work assignment separately. When the project budget is divided among many experts, the number of paid hours per expert diminishes, which has caused the following challenges:

"In one of my projects there was a good expert, but a high-priced expert, who could not really get familiar with the project in that time. There came almost like a standard answer which always comes, like these and these things are important in this."

“At least I have gone over in every project, the hours budgeted for me have been exceeded by at least four times, remarkably more hours have been used than budgeted.”

“But it was still difficult when there were quite many, and on a shoestring, and one can see that they have certainly already used that sum to the ideas. But nothing had yet been accomplished.”

In order to meet the project objectives, and to maintain the interest of project leaders and experts to participate also in the following projects, it would be important to have the expected contributions and received compensations in balance.

Project leaders also hoped they would know more about the competence of experts. There are experts’ profiles on Solved website but the information is often insufficient. In addition to areas of expertise, such as “water” or “energy”, project leaders hoped information of other skills and strengths, which would help to build an ideal team and to delegate tasks during the process. Also a possibility to give feedback to experts on the platform, or some other system for quality assurance, was hoped for.

5 DISCUSSION

Throughout the previous chapters, I have analysed how dispersed experts communicate and integrate knowledge across a short-term co-creation project, and how the process can be facilitated by project leaders and supported by the surrounding context. In this chapter I summarize the key findings by presenting a process model, and by replying to the research questions. The empirical findings are also discussed in relation to existing research of knowledge creation, virtual knowledge processing, and time-constrained group processes aiming for novelty.

5.1 Knowledge co-creation process: from ideation to solution

This study shows that dispersed experts, working for the first time together as a group, can co-create a multidimensional conceptual design in a short period of time through technology-mediated communication when the knowledge co-creation process is well managed. In this chapter the key empirical findings are presented as a process model (figure 13)[3], which is complemented by a describing matrix (table 6). The core of the model is the knowledge co-creation process consisting of two phases; an unbounded phase and a solution-oriented phase. The reply to the research problem, ***How a temporary group of experts co-creates knowledge in virtual project environment, and how is the process facilitated***, is culminated in these two phases. Unbounded and solution-oriented phases are distinct from each other in terms of how experts communicate and process with knowledge, and how the process is facilitated by project leaders. The answer to the research problem is built through replying the five sub-questions. Therefore, next the process model and the describing matrix are presented, and the research questions are replied.

[3] To understand where the building blocks of the process model come from, please see appendix 7 for *facilitative actions*, appendix 5 for process *phases*, figures 4 & 8 for co-creation *steps,* appendix 4 for *conceptual design artifacts* (and the final conceptual design solution), and appendix 8 for *support in virtual project environment*.

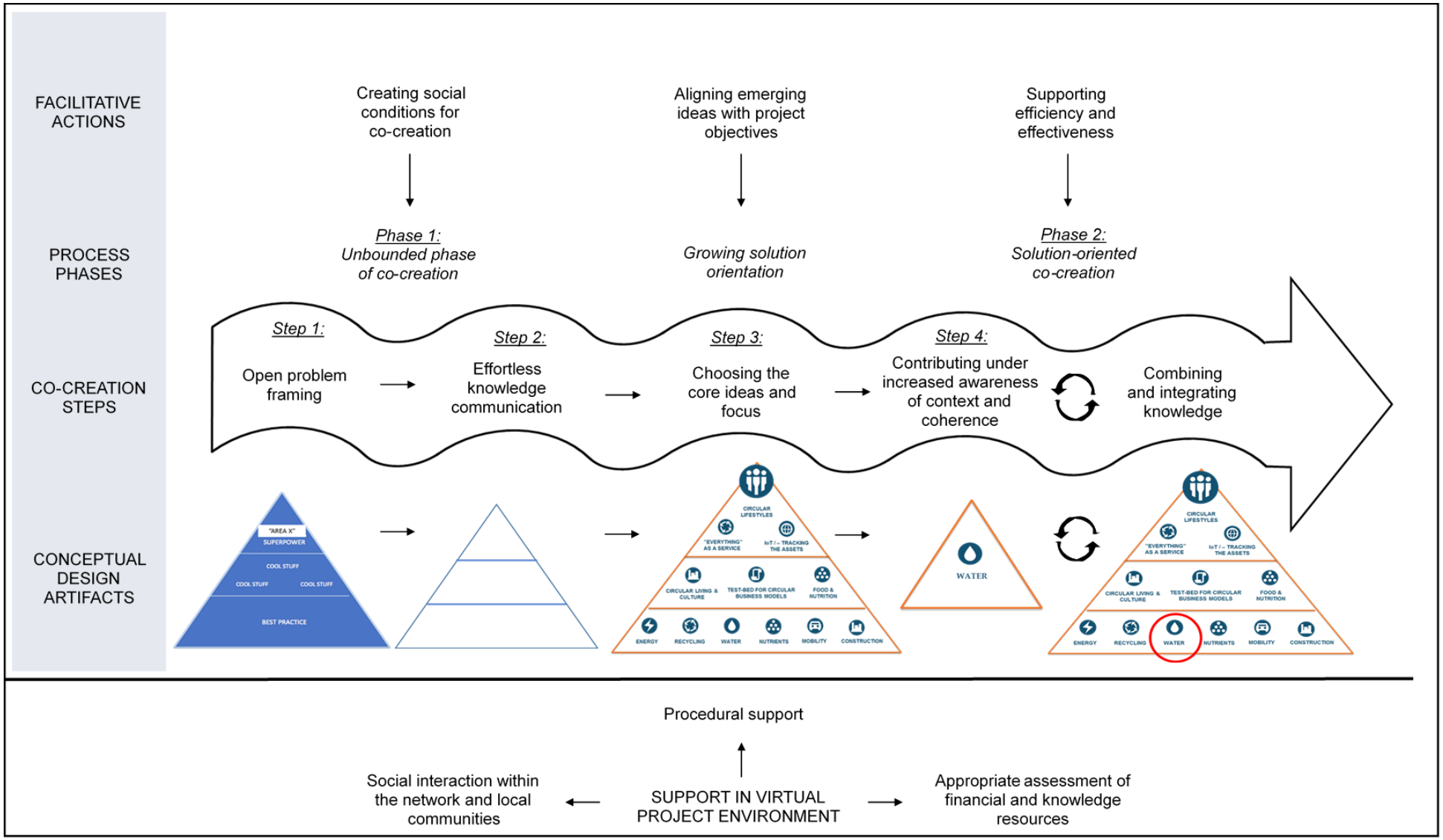

Figure 13 Knowledge co-creation process and its facilitation in virtual project environment

Table 6 Comparison of unbounded and solution-oriented phases

	UNBOUNDED PHASE OF CO-CREATION	SOLUTION-ORIENTED CO-CREATION
Knowledge co-creation objective	Creating a shared, rich knowledge basis	Creating a knowledge solution
Type of knowledge	Diverse ideas and pieces of knowledge from different contexts	Coherent solution with assorted ideas and knowledge applied to the context
Primary communication mode	Asynchronous, text-based communication	Asynchronous communication (shared artifacts) & synchronous communication (oral discussions)
Primary knowledge processing mode	Sharing individual knowledge	Creating collective knowledge
Nature of process	Straightforward	Iterative
Working mode and the level of complexity	Autonomous, individual-centric, effortless	Interdependent, collective, requiring more effort

Knowledge co-creation process starts with an unbounded phase, in which open problem framing (step 1) enables effortless knowledge communication (step 2). This phase is about sharing diverse ideas and pieces of knowledge from different fields and contexts to create a shared and rich knowledge basis between dispersed experts, not knowing what the others know since lacking of shared working history. Project leaders facilitate the unbounded phase by creating supportive social conditions, such as a positive and compelling atmosphere in which everyone's contributions are expected and appreciated. Choosing the core ideas and focus (step 3) grows the orientation towards the solution, and thus is a turning point in the nature of co-creation. Project leaders facilitate the group to go into the right direction by constantly communicating expectations and appraising the emerging ideas.

Solution-oriented co-creation is an iterative phase between experts contributing under increased awareness of context and coherence (step 4) and integrating knowledge contributions (step 5). Project leaders act to facilitate the experts to use the limited hours effectively throughout the process, and increasingly towards the end.

For example, in the case, project leaders usually did the integration of knowledge by merging separate PowerPoint documents into one, and the group then discussed about further modifications and refinements. The group shared PowerPoint documents and discussed based on them already at the unbounded phase of co-creation. So, although distinctive features between the two phases of co-creation, unbounded and solution-oriented phases, can be identified, they should not be considered as completely opposites. For example, although working modes of the two phases differ from each other (table 6), the unbounded phase is not entirely individual-centric nor is the solution-oriented phase entirely collective. Both phases include working alone and working together, it’s more about the goal and mindset that shift (increasing awareness of context and coherence affecting how an individual contributes). Similarly, the group did have oral discussions also at the unbounded phase but then the emphasis was on text-based communication on the digital project platform.

The curvy outline of the process model describes how the process is not as straightforward as it may seem when presented as a process. Particularly if many experts would join in the middle of the process, which did not happen in the case (only the “hangaround” expert joined during the process), there might be more movement inside the process. Step 6 would be the finalizing work, but since it was, at least for the most parts, conducted by the project leaders without the group of experts, it is not considered to be a part of the knowledge co-creation process.

Replying to RQ1:

Knowledge co-creation proceeds between dispersed experts from creating a knowledge basis to creating a knowledge solution

Dispersed experts begin knowledge co-creation by forming a shared, but loosely defined, understanding about the task and the problem at hand. Keeping the problem framing open at the beginning allows dispersed experts, not necessarily sharing working history together, to communicate knowledge effortlessly, and to create a rich and shared knowledge basis on the digital platform. Asynchronous knowledge communication includes writing ideas, posting documents, and sharing www-links to external knowledge sources. At this phase, experts do not need to know in which way, if at all, the particular piece of knowledge is used in the final solution. However, in order to create a solution responding to the client's needs, it is necessary to align emerging ideas with project objectives, and to choose the core ideas and focus. Growing solution orientation is a turning point in the nature of co-creation, which henceforth requires more collective effort and emphasis on practicality over creativity. A solution is created through iterative process of contributing under increased awareness of context and coherence, and integrating knowledge contributions.

Replying to RQ2:

Virtual platform is used for asynchronous knowledge sharing for being fast and flexible, whereas conference calls are used for interactive discussions

A virtual platform forms a collaboration "place" for dispersed experts collaborating at a distance. It increases continuity in knowledge processing, and offers experts flexibility, as each expert can share, read and comment knowledge at any time. Audio- /videoconferencing is more interactive and offers more social cues than writing on a platform, thus facilitating explaining and interpreting meanings. This makes synchronous discussions important in the process of knowledge co-creation. However, they are also challenging in terms of using the limited hours effectively. Therefore, a working model of shifting between asynchronous written

communication and synchronous oral discussing, in a balanced way, facilitates staying within the time limits while supporting the needed level of shared understanding.

Replying to RQ3:

Artifacts and objects shape communication and facilitate knowledge co-creation between dispersed experts

Digital platform allows interacting with a group of people despite of different space and time. Text-based knowledge, once shared on the platform, stays there for further reading and commenting, offering continuity for interaction. In addition to the support of the platform, co-creation is facilitated by shared artifacts. Conceptual design artifact with a dual status of structuring and compiling (identified in the case) is an example of a boundary object being central to the knowledge co-creation process. It facilitates shifting between individual contributing (areas of diverse expertise) and collective integrating (the coherent entity). Artifacts can be used to increase communication effectiveness in knowledge co-creation process. PowerPoint slides, for example, encourage experts to share enriched knowledge in a compact format rather than posting long reports on the platform. Headlines or categories can be used to guide experts to share knowledge regarding a certain topic. An adaptable and loose enough artifact can operate as a common reference increasing shared understanding between dispersed experts, without limiting their creativity, or causing challenges in case some changes (e.g. in client's preferences or priorities) occur along the process.

Replying to RQ4:

Project leaders facilitate a knowledge co-creation process by enhancing social conditions, giving direction, and supporting efficiency and effectiveness

By creating social conditions for co-creation project leaders can facilitate open and active participation of experts not necessarily knowing each other. There may be no

opportunity to meet face-to-face due to geographical distances, nor much time for relaxed chatting. Letting experts know with whom they are working with, at least in terms of knowing each other's areas of expertise and roles in the project, as well as promoting a positive and compelling co-creation atmosphere, are facilitative actions of project leaders. By communicating expectations to experts, and by aligning emerging ideas with project objectives, project leaders facilitate the group to move into the right direction. Facilitative actions and responsibility taking of project leaders are needed to keep the group progressing. The idea generation at the unbounded phase of co-creation is effortless and engaging work, and without clear guidance the ideation phase easily extends too much, resulting in to a massive knowledge basis and too little time for the iterative process of collective knowledge creation. Therefore, project leaders need to take care of choosing the core ideas and keep the group focused. Supporting efficiency and effectiveness, for example through shared communication practices and an adaptable knowledge structure, is one of the main tasks of project leaders when facilitating a temporary co-creation process with time constraints.

Replying to RQ5:

Virtual project environment lacks of continuity in work processes, relationships and agreements, and thus contextual support is needed

A new collaboration situation in which dispersed experts share no working history, nor have shared collaboration or working practices, easily causes ambiguity. Thus, procedural support, in forms of supportive technology and administrational assistance, is needed from the "host" or other organizing party to make the process more clear and smooth. By creating opportunities for virtual and physical meetings and discussions, and by promoting social interaction between members within the global network and the local communities, the host organization facilitates network members to set up new projects in a more self-organized manner. However, the lack of continuity in social relationships and agreements with both experts and clients makes setting up new projects demanding. Project leaders, possibly temporary workers themselves, need support from the "host" in evaluating the

competence of experts, and aligning of compensations and contributions with the project objectives.

5.2 On expertise sharing and knowledge creation in virtual context

As an alternative perspective to categorizing knowledge either as tacit or explicit (e.g. Nonaka 1994), many scholars have argued that tacit and explicit knowledge should not be seen as two separate types of knowledge, but rather as a continuum (Jasimuddin et al. 2005, 104). Empirical findings support the understanding of knowledge as a continuum because the expertise knowledge project members shared virtually along the process does not fit with the traditional ideas, particularly the most rigid descriptions, of either tacit or explicit knowledge. The knowledge experts share, even when being written ideas or documents (referring to explicit knowledge, e.g. Nonaka 1994), is usually domain-specific and tacit in a sense that it is not easy to fully understand by someone not having similar expertise. From an objectivist perspective, explicit knowledge, such as an electronical document, is fully understood by the receiver even when being isolated from the sender, and not having any other form of communication or interaction with the sender (Hislop 2002, 168). The case observations of knowledge sharing do not fully fit to this description, for example, researcher's notes from a conference call (4.11.) reveal that attending project members, even though presumably having similar expertise to some extent, did not understand slides that one (absent) expert had prepared for the meeting.

It seems that oral discussions are to some extent needed to interpret the written contributions, and that the importance of oral discussions increase towards the end of the knowledge co-creation process. Probably it is because of the increased level of required understanding. It is said that information technology would not transfer the tacit elements of knowledge, and therefore the full meaning of knowledge is not communicated virtually (Hislop 2002, 174). Perhaps the full meaning of knowledge is not required to be communicated at the *unbounded phase* of co-creation, and that is partly why the knowledge communication at this phase feels effortless. Practically speaking, participants understanding the main points of ideas or reference cases

temporary colleagues share on the platform is most likely sufficient for creating a knowledge basis, i.e., achieving the objective of the *unbounded phase*. On the contrary, at the *solution-oriented co-creation* participants need to understand each other's knowledge and requirements of the context (e.g., realities and wishes of the client) more profoundly in order to be able to contribute under increased awareness of context and coherence. Creating a practical solution out of the diverse knowledge contributions requires some level of learning from others' areas of expertise, and "effort of reflecting or putting into practice" (Nonaka et al. 2008, 24), thus referring to knowledge creation mode of 'internalization' (Nonaka 1994). Not necessarily the whole co-creation group need to engage with processes of learning or modifying knowledge from abstract or general to more practical, but the core people do. In the case, project leaders were responsible for compiling the final report and presented the solution to the client, and they guided discussions and integrated knowledge throughout the process. Therefore, particularly they needed to have a good understanding of the whole solution.

Virtual knowledge sharing and processing, particularly in a fast-paced project with unfamiliar project members, can be quite challenging, as has been discussed throughout the thesis. What made it possible, and rather successful, in the case project, has to do with facilitative actions of project leaders and the contextual factors. Some project members had similar expertise which facilitated shared understanding and promoted (virtual) discussing between them. Many project members commented in interviews that there was a good team spirit, excitement and even trust, and that people shared knowledge openly. This might have been related to the existing connections between project participants (table 2). Most of the members had experience of participating in a Solved project before so they probably had some understanding of project phases, and how one communicates and shares knowledge on a virtual project platform. Also the knowledge co-creation task, conceptual design, is something which end result will be presented in a written format (a written report and a PowerPoint presentation in the empirical case), so, why then the knowledge couldn't also be shared in a written format along the process. In other words, although experts shared domain-specific knowledge, it was not "too tacit" to be recognized and converted into a written format, i.e., 'externalized'

(Nonaka 1994). Above mentioned contextual factors – a degree of common knowledge between individuals, a degree of trust and willingness to share knowledge, and a degree of explicitness of the knowledge – made the case what Hislop (2002, 174) calls the 'best case scenario' what comes to knowledge sharing via information technology systems. Another group in a similar situation may face more challenges in processes of virtual knowledge sharing and creating.

In addition, there were some non-virtual meetings which may have had a great impact on the knowledge co-creation process although for most of the group members co-creation activities were solely virtual. Applying again Nonaka's knowledge creation modes (figure 1), 'socialization' occurred between the two project leaders. Project leaders worked closely together, and were regularly in social interaction including non-verbal communication, so it is likely that they have grasped more of each other's highly tacit knowledge than what occurred through technology-mediated interaction. Also there were two face-to-face 'brainstorming' meetings between one expert and the project leaders *"to just sit down and do some drawings or to really just have enough time…"* It is known that the first version of the conceptual design artifact was created based on these face-to-face discussions.

5.3 On balancing with 'openness' in time-constrained group processes aiming for novelty

Concept design can be considered as a knowledge creation task but also as a problem solving task. "A new concept is a solution to a problem that has not yet been solved or which so far has been solved in an unsatisfactory way" (Rosted et al. 2007, 27). In the following section, I discuss about the importance of having "openness", as well as being able to balance with it, in time-constrained group processes, whether the task being characterized as a problem solving, a knowledge co-creation, or some other task aiming for novelty.

In the literature of creative processes the value of the beginning's openness, "broadening perspectives and opening up possibilities before refining, narrowing and making realizable" (Nielsen 2012, 88), is well recognized. The unbounded

phase of co-creation, in which experts are allowed and encouraged to share any ideas and pieces of knowledge, no matter how realistic or well-thought-out, has an important role in knowledge co-creation process aiming for creative and novel solutions. Original innovations are produced outside an expert's "cone of expectation", and are not results of an expert's predictive logic (Austin et al. 2012, 1517), and therefore experts should be encouraged, not only to share knowledge they already possess (e.g., case benchmarks and domain-specific knowledge or insights), but to really think "outside the box" and surprise themselves too. Project leaders can facilitate this type of co-creation by creating a positive atmosphere and promoting experts getting to know each other.

At the unbounded phase of co-creation participants communicate knowledge on the digital platform effortlessly. Experts do not need to know in which way, if at all, the shared piece of knowledge responds to the client's needs or will be a part of the final solution, i.e., there are no requirements for knowledge sharing in terms of being aware of and considering the context or coherence. Text-based knowledge contributions, in forms of short writings and documents, are posted on the digital platform with no specific order (other than a chronological order). Digital platform may facilitate what Austin et al. (2012, 1515) call "valuable accidents" when it acts as a means for collecting, i.e., accumulating and saving interesting ideas without knowing exactly how they will be later used, and organizing them loosely since searching through them may later give better ideas. Therefore, platform discussions may facilitate valuable accidents within a particular project but also in other projects in case experts have an access to, and are able to grasp the meanings of, previous or parallel project discussions.

Naturally, before the dispersed experts are virtually gathered together and the knowledge co-creation process begins, there must be a need or a problem identified to have a co-creation task in the first place. Nevertheless, in the empirical case the group had *"almost free hands from the client"* (Project Lead on the platform week 1), and the experts were allowed to share and search for practically any knowledge until the point of choosing the core ideas and focus. Problem framing, in the way Schön (1988, 182) describes it – setting design situation's boundaries, choosing particular things and relations, and imposing on the situation a coherence that

guides the following actions – occurs at the midpoint of the process, turning the nature of the co-creation more solution-oriented. The importance of temporal milestones, particularly the midpoint, has been emphasized also in previous research of groups facing a deadline (Knight 2015, 112). Recognizing the two phases and their distinct objectives may help group participants to adjust their communication and knowledge processing actions accordingly. Similarly, project leaders can better balance with “openness” when identifying the two phases and being able to communicate them to project participants.

According to von Hippel and von Krogh (2016, 214-215) under conditions in which organizational, technical, temporal or other constraints remarkably limit the search for need-solution pairs, formulating problems before solving them may be the most efficient way. The need to manage the tension between efficiency and flexibility is a well-known leading challenge (Eisenhardt et al. 2010). As the empirical findings of the time-constrained knowledge co-creation process show, it is vital to move early enough from unbounded phase to solution-oriented co-creation. Although the actions of project leaders supporting efficiency and effectiveness, such as creating a knowledge structure, respond to the needs for more clarity, project leaders should be careful not to diminish “openness” too much at the early phase of a group process aiming for novel solutions.

5.4 Evaluation of the study

It is important that readers can evaluate the quality and trustworthiness of research results. Next I evaluate the quality of implementing and reporting the empirical study by applying the terms of reliability and validity in those parts as they fit the qualitative case study context. Then I evaluate the theoretical and practical value of the study.

5.4.1 Implementing and reporting the empirical study

Based on the principles of reliability and validity, Yin (2003, 34) suggests case study tactics to be applied throughout the study. Each tactic relates to data collection, data analysis, or the composition of the research design. Triangulation by data source allows the researcher to check the degree to which each source confirms, elaborates and disconfirms information from other sources (Mabry 2008, 222). In the case, it was important that I was able to interview each participant of the project (project leaders and all experts) to hear everyone's personal experience. Methodological triangulation means checking between data collected using different methods (Mabry 2008, 222). Research questions were replied by collecting and analysing data from multiple informants, and interview data was complemented with the understanding received from the platform discussions (table 3). Interviews, platform discussions and virtual meetings all told the same story about the knowledge co-creation process, but each of them provided information from a slightly different perspective, and therefore complemented each other. Thus, from my own experience, I can only agree with all the authors who recommend using multiple sources of evidence to make case study findings or conclusion more convincing and accurate (e.g. Yin 2009, 114-116). The ways in which data collection and analysis were conducted improve both construct validity and internal validity of the case study, and the detailed documentation of them responds to requirements of reliability (Yin 2003, 34).

External validity of a case study relates to the research design and analytical generalization of research results. Statistical generalizations cannot be made based on a case study but a researcher can try to link a particular set of findings to a certain domain, a broader theory. (Yin 2003, 34, 37) In chapter 5.2 I discuss the findings in relation to the knowledge creation theory of Nonaka (1994) and literature of expertise sharing and knowledge processing in virtual context. Gioia et al. (2013, 24) argues that many concepts and processes are similar across domains, and it is possible to generalize from a small sample, even from a case study if "the case generates concepts or principles with obvious relevance to some other domain". In chapter 5.3 I argue that a conceptual design task can be considered as a knowledge

creation task but also as a problem-solving task, and discuss about the importance of having “openness”, and being able to balance with it, in any time-constrained group process aiming for novelty.

However, assessing reliability and validity should not be made too rigidly, after all, new knowledge is the justification of a research at the end (Koskinen et al. 2005, 253). Rather than making generalizations or providing a singular truth, this study has quite well succeeded in having dialogue among perspectives, and offering a rich case description from which one can learn from, and which illuminates the current topics (Patton 2002, 46, 546). The case study has been implemented and reported carefully. Throughout the methodological and empirical parts of the thesis, I have tried to give a rich and detailed description of the contextual factors which might have affected the process. This includes, for example, a description of the co-creation group and relationships between the participants, a description of virtual and non-virtual communication between participants, and a description of the role of Solved in the process. Therefore, readers have the possibility to evaluate to which extent the empirical setting is similar to the ones they are engaged with, and then, to which extent the findings might be applicable to their contexts.

5.4.2 Theoretical and practical value

The findings of this thesis discuss with the literatures of knowledge co-creation, time-constrained group processes aiming for novelty, and new forms of organizing – in the specific context of virtual project environment. This was a starting point of theorizing a knowledge co-creation process in the context of virtual project environment. According to Hubers et al. (2016, 63), as well as my own search efforts, there are not many attempts to make the process of knowledge creation a concrete and observable phenomenon.

An important distinction between unbounded and solution-oriented knowledge co-creation phases was made. This distinction is likely to apply in other Solved projects, and to be interesting to consider also in other time-constrained group processes aiming for novelty, as discussed before. The success of a fast knowledge co-

creation process relies much on the knowledge experts possess, but also on “how members know and integrate their individually held knowledge” (Okhuysen & Eisenhardt, 384). Due to the process perspective of this study, the perspectives of “knowing” in the situation and integrating knowledge through communicative actions and material objects are highlighted. Through facilitative actions, project leaders help the group in the process of “knowing” and integrating the knowledge contributions under increased awareness of context and coherence. Project leaders have a significant role in the process of turning the individually possessed knowledge and expertise into a practically relevant solution responding to a client’s needs.

Although virtual project environment enables flexible and temporary collaboration between geographically dispersed experts, the present study shows that virtual project environment is also a challenging context in which versatile facilitation and support is needed. Thus, I agree with other authors (Schreyögg & Sydow 2010; Eisenhardt et al. 2010) who conclude that new organizational forms should not be simplified with too much emphasis on fluidity, virtuality, and adaptability. Instead, as this study suggests, levels of “openness” and effectiveness need to be balanced during a knowledge co-creation process. Without facilitation actions of project leaders, the unbounded phase would easily be prolonged causing too many diverse ideas and too little time for creating a coherent and context-applied solution, thus impeding the likelihood of the project success. In the virtual network of experts, members can set up and run projects in a self-organized manner, however, in practice, support from the “host organization” is often needed in order to succeed. Without this support, discontinuity in social relationships, lacking of shared practices, and the need to do project-related agreements and finding the experts with the right kind of knowledge can turn out to be the opposite of fluidity and flexibility.

5.5 Limitations and suggestions for further research

Increasingly clients, citizens, and other stakeholders actively participate in virtual co-creation projects. In the case study, the representatives of the client did not participate in discussions on the platform nor on group conference calls, and that's why their role in the co-creation process was not studied. Based on the platform discussions between project leaders and experts, and based on the interviews, the role of the clients was close to what Aarikka-Stenroos and Jaakkola (2012, 20) describe in the co-creation process of knowledge intensive business services; Clients leave solution formulation to experts counting on their opinions, evaluations and suggestions, however, they play an important role in articulating own industry knowledge, interests and other details, and thus influence in finding and choosing "the right path" in the problem solving process. Not interviewing the representatives of the client, and thus leaving their role to a less attention, can be considered as a limitation in this study aiming to create a holistic understanding of the knowledge co-creation process.

Virtual project environment was identified to be a challenging context in which experts have needs for facilitation, and in which project leaders wish for more support from the organizer. The perspective of identifying particular needs of different parties collaborating in virtual project environment, could be continued in the future studies. In that context, also the needs of clients, and how the needs are responded by project leaders or other process participants, could be studied, as it would be enriching for co-creation to have the client actively involved in the process.

The importance of keeping the problem framing open and loose at the beginning of the process to enable more creative and novel solutions has been discussed in this study. How much "openness" and space for "valuable accidents" there can be in temporary knowledge co-creation process, would be an interesting research question to study further. More specifically; how difficult, engaging, motivating or risky different parties (experts, clients, project leaders) consider the unbounded phase of co-creation? In this study, knowledge communication on the virtual platform was active at the beginning, and some experts described the ideation

phase as fun working. However, it was noticed that not all experts participated in the open ideation on the platform.

The knowledge co-creation process was examined rather closely at this study by collecting data from the project platform (from the beginning to the end of the process), as well as interviewing each participant of the co-creation group. However, the fact of not having data of one-to-one or mini-group discussions, nor observational data of group conference calls at the beginning of the process, may have caused missing some details. Thus, further studies are needed to create a more nuanced understanding of the knowledge co-creation process and the discussions in the course of it.

This study shows how dispersed experts, working for the first time together as a group, successfully achieved a knowledge co-creation goal in a short period of time. The conceptual design solution was created through writing comments and sharing documents on a digital platform and discussing them in conference calls. Advanced virtual collaboration tools were not the “hero ingredient” in the story. Knowledge co-creation was successful due to process phases, co-creation steps, conceptual design artifacts, and facilitative actions of project leaders, which all supported the balance between “openness” and effectiveness, and shifting between individual and group activities. Also further studies of similar group processes likely benefit from considering the context, the sequences, the driving forces, and the turning points of the process (Bidart et al. 2013), as “no project is an island” (Engwall 2003).

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Appendix 1 Interview questions: Case interviews

BACKGROUND QUESTIONS

1. **Would you start by telling me shortly who you are, and why you were involved in the project?**
2. **Did you know the other project participants from before, or did you get to know some people first time during the project?**

COMMUNICATION AND KNOWLEDGE SHARING

3. **Could you describe communication and interaction between project participants, how was it?**

   What kind of knowledge different participants brought into the project?

   What kind of knowledge was valuable for the project?

   How knowledge was shared, and how easy or difficult it was?

   How were new ideas generated?

   What helped to share participants' knowledge in practice?

   Could you tell an example of a situation, when sharing knowledge was particularly successful, on your opinion?

4. **What kinds of challenges you experienced yourself or noticed occuring related to knowledge sharing, or communication in general? Can you describe an example?**

   What was particularly difficult?

   How difficulties were overcome?

5. **What was the role or importance of the digital collaboration platform in the co-creation process, compared to other ways of communicating and sharing knowledge?**

   What advantages or disadvantages the platform brought?

   How was the platform utilized in knowledge sharing and in project in general?

   How would you describe your working time was divided?

   a) Alone vs. together with other participants
   b) Through the platform vs. through other virtual tools (e.g. phone, email..)

c) Face-to-face vs. virtually

If you think about the collaboration on the platform, what did work well, and what should be developed according to your experience?

PROJECT PHASES AND PRACTICES

6. **What kinds of roles, practices and habits did the project group have, and how you experienced them?**
7. **In which parts would you say that collaboration in this project was successful, and what could have been done differently?**
8. **Which phases or steps of the project you consider the most important ones, and why?**
9. **Finally, could you describe how the project group ended up with the final solution?**

+ 10. Is there something else that would be good to understand?

Appendix 2 Interview questions: Individual interviews of project leaders (all interviewees are Finns)

TAUSTAKYSYMYKSET

1. **Minkälaisissa Solved-projekteissa olet ollut projektivetäjän roolissa?**

   Minkälaisia projektit olivat kooltaan ja kestoltaan?

   Millainen oma roolisi oli näissä projekteissa?

   Kuinka onnistuneena pidät näitä projekteja?

   Miten ulkoiset ja ryhmän sisäiset tekijät mielestäsi edesauttoivat tai hankaloittivat projektin onnistumista?

KOMMUNIKOINTI JA TIEDON JAKAMINEN

2. Voisitko kuvailla millaista kommunikointia ja vuorovaikutusta projektin osallistujien välillä oli?

3. Mitä kanavia pitkin olitte yhteydessä ja kuinka usein?

4. Tapasiko koko ryhmä tai osa ryhmän jäsenistä kasvotusten projektin aikana? Mitä vaikutusta sillä mielestäsi oli?

5. Millaista tietoa asiantuntijat toivat projektiin, ja millä tavoin he käytännössä jakoivat tiedon muulle ryhmälle? Mikä oli projektille arvokasta tietoa?

6. Millaisia suullisia ja kirjallisia keskusteluja projektissa käytiin?

7. Kuvailisitko jotakin projektin aikana käytyä keskustelua, joka on jäänyt sinulle erityisesti mieleen. Mikä siinä oli erityistä?

8. Millaisia keskusteluja käytiin koko projektiryhmän kesken, ja millaisia pienemmällä porukalla?

KONSEPTIN YHTEISKEHITTÄMINEN JA FASILITOINTI

9. Kuvailisitko ryhmän toimintaa ja yhteiskehittelyn luonnetta projektin eri vaiheissa?

10. Miten kommunikointi ja tiedon jakaminen muuttuivat projektin edetessä?

11. Miten oma roolisi muuttui projektin aikana?

12. Millaista ryhmän jäsenten osallistuminen oli projektin eri vaiheissa?

13. Minkälaisia haasteita konseptin työstämiseen liittyi?

14. Miten pyrit edesauttamaan ryhmän toimintaa ja konseptin kehittymistä?

15. Mikä sinulle projektivetäjänä oli helppoa, ja mikä vaikeaa?

16. Minkälaista tukea, työkaluja, tai erilaista toimintatapaa toivoisit projekteihin jatkossa? Mitä tekisit itse toisin?

Appendix 3 Interview guide: Focus groups of project leaders

Theme	Elaborate question	Examples of possible follow-up questions	Purpose
Introducing the approach and proceeding of the focus group discussion – 5 minutes			
Experiences of co-creation projects	What does first come to your mind when you think back to the project(s) in which you were a project leader, and recall some discussions, knowledge sharing and participation of project members? What can you best remember, and why?	Why do you think that happened? How did it affect the project, according to your understanding?	To open and direct the discussion to participants' experiences. To understand what was meaningful, either successful or less successful, in the projects.
Introducing the first theme, short introductions of participants, and their first shared experiences – 10 minutes			
Role and actions of project leaders	How would you describe your role and actions in different phases of the concept development process?	What did you do to help the group to achieve its goals? What was challenging for you as a leader?	To understand the possible different experiences of project leading, and to form a more comprehensive understanding of the project leader's role based on actions.
Introducing the second theme, 1 minute thinking time and discussion of the theme – 15 minutes			
Concept development process	When you think about the concept development process from the first shared ideas to the final concept solution, what is the most challenging for a co-creation group, according to your experience?	What makes it difficult, according to your view?	To understand the nature of knowledge co-creation of concept development, and to recognize the challenging aspects that need facilitation.
Introducing the third theme, 1 minute thinking time and discussion of the theme – 15 minutes			
Knowledge co-creation practices	How did the group co-create the concept in practice? What is your view of which practices worked well?	Which practices involved the whole group, and which did not? What type of interaction and knowledge processing did the successful practices include?	To understand the co-creation process in practice, and how it can be facilitated (with which types of practices).

		What was successful about the ways project members communicated and collaborated?	
Introducing the fourth theme, 1 minute thinking time and discussion of the theme – 15 minutes			
Lessons learned from the previous projects	What have you learned about people's thinking, feeling and behaviour when acting as a project leader? According to this knowledge, what would you do differently in the next projects, if possible?	Further questions about the evolving ideas.	To produce ideas of how to facilitate the co-creation process by taking into account social, emotional and cognitive aspects.
Introducing the fourth theme, 1 minute thinking time and discussion of the theme – 25 minutes			
Ideas for efficient knowledge co-creation	How the available knowledge and expertise of project members could be more efficiently used in projects? How project leaders could help the group to move faster from brainstorming to actual concept development? What actions are needed to do that? What would be the ideal balance between creativity and efficiency? How the process should be changed to support that?	Further questions about the evolving ideas.	To produce ideas of how to facilitate fast knowledge co-creation, and to balance between creativity and efficiency.
Thanking participants for the discussion, and ending the focus group – 5 minutes			

Appendix 4 Timeline of the process

A few comments on the platform around 1,5 weeks before the kick-off.

Kick-off meeting. Project leaders meet face-to-face with the client, experts join the meeting virtually. Due to technical difficulties all experts are not able to join from the beginning.

WK 1

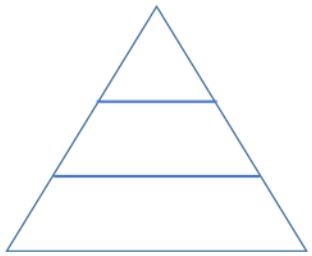
- **Transferring background knowledge.** PL transfer general information regarding the project (e.g., a project plan) and background material from the client (e.g., a vision). Communicating how and why to inform and motivate the experts.
- Brainstorming begins by two experts discussing about definitions of the key concepts, as well as where to start and what to include in the co-creation.

WK 2

- **Suggesting a triangle-approach to create a visual structure and hierarchy of ideas.** The 1st version of the three-level triangle is created as a result of a face-to-face meeting between project leaders and one of the experts.
- Brainstorming on the platform is vivid, but not everyone participates in it.

WK 3

- **Collecting diverse ideas.** Each expert is asked to give an input to the triangle. PL reminds that active contribution is now needed, and asks each expert to fill in the PowerPoint template with own ideas, and then post it on the platform. Most of the experts share ideas on the platform in some format but not everyone posts a filled template.



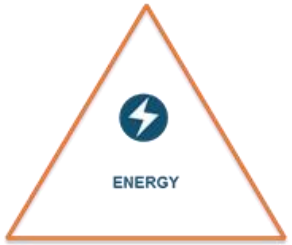
WK 4

- **Deciding a direction and areas of focus.** The triangle now contains the elements that will be concentrated on. It's a combination of ideas presented in previous weeks and in the background material shared by PL.
- PL had a meeting with the client, who approved the ideas so far and gave a permission to move forward.

Note: A shift in the nature of co-creation, growing solution-orientation

WK 5

- **Dividing work and areas of responsibility** in order to utilize everyone's expertise and anchor it more explicitly to the emerging concept solution. Each element of the pyramid is now separated from the whole and labelled with an expert's name, e.g., one expert should now prepare the slide regarding "energy". *Note: Sharing knowledge and expertise in the form of brainstorming ideas, or previously made or other existing reports and benchmarks is easy, transforming it into concrete solutions is more difficult.*



WK 6

- **Discussing at more concrete and context-specific level.** Focusing on each topic separately while maintaining coherency is facilitated by one-to-one discussions, group virtual meeting, and by sharing key points of discussions on the platform. Balancing between concrete, fairly detailed solutions and more high-level proposals.
- Triangle version 2 is collectively chosen (small differences between the two versions).

WK 7

- **Leaving collective discussions aside.** "To save everybody's workload" PL will email/discuss with all experts separately to finalize the concept. They do not anymore actively share knowledge and slides on the platform.

WK 8

- **Finding support for the selected ideas and suggestions.** PL shares a link to Google Docs folder containing the presentation and report templates. There is still collective effort to some extent, but most of the discussions seem to be now between PL and experts in separate one-to-one/ small-group emails or phone calls.

WK 9: Time of experts "purchased" for the project has run out/ is running out. Some experts will still contribute to some extent, but most of the modification and finalizing work is on responsibility of PL.

WK 10: Final rush. Many issues are open and a lot of work to do for PL just 4 days before the final deadline.

WK 11-12: Solved. PL deliver the concept solution, and do the last modifications on the presentation and report according to the client's wishes.

PL = project leader / project leaders

Conceptual design solution (final)

Appendix 5 Data structure: Knowledge co-creation process (case data)

KNOWLEDGE CO-CREATION PROCESS	AGGREGATE DIMENSIONS
2nd-order theme: OPEN PROBLEM FRAMING	**UNBOUNDED PHASE OF CO-CREATION**
1. There have been a lot of different visions, and around them new ideas and everything else has emerged	
1. The definition or boundaries of the concept were not clear at the beginning	
1. I did not know which direction to go, or what the objectives are	
1. At the beginning it was more like just throwing some ideas without knowing where to go	
1. When there is a broader scope, it is easy for people to quite freely share and throw ideas	
2nd-order theme: EFFORTLESS KNOWLEDGE COMMUNICATION	**UNBOUNDED PHASE OF CO-CREATION**
1. Sharing knowledge and throwing ideas felt easy and informal	
1. Sharing knowledge and ideas started actively on the platform	
1. Knowledge sharing in the group was open	
1. At the beginning there was a good vibe on the platform when ideas and example cases were shared and discussed	
2nd-order theme: CHOOSING THE CORE IDEAS AND FOCUS	**SOLUTION-ORIENTED CO-CREATION**
1. To get the team to go in a crystallized direction after ideation	
1. Narrowing down or choosing among ideas was difficult	
1. It's very complicated to knit together the three potential core concepts	
1. It was important that we found our own message of what is 'the thing' in this	
1. Focusing on the selected items of the concept after broad ideation is important but difficult	
1. Certain focus areas were diluted as the project evolved	
2nd-order theme: CONTRIBUTING UNDER INCREASED AWARENESS OF CONTEXT AND COHERENCE	**SOLUTION-ORIENTED CO-CREATION**
1. Making concrete thoughts or propositions out of the ideas requires different type of pushing than just discussing or throwing ideas	
1. Ideation is fun and easy working but producing own content feels to be a bit more challenging	
1. I mirrorred to contributions of others, to keep the coherency	
1. Giving specific knowledge, or modifying content, is more challenging than sharing references and links	
1. For me contributing at the end is difficult because everything is connected to everything	

2nd-order theme: COMBINING AND INTEGRATING KNOWLEDGE	**SOLUTION-ORIENTED CO-CREATION**
1. It becomes a real project with real solutions when ideas are combined to this knowledge of experienced experts	
1. Integrating knowledge, pulling all together and drawing the conclusion is challenging	
1. Challenge of balancing between detailed and more general level of knowledge	
2nd-order theme: PRODUCTIVE PRIVATE MEETING	**SYNCHRONOUS DISCUSSIONS**
1. I had a very productive meeting with one of the team members	
1. At the lunch meeting we came up with 'the wow' idea, and got a focus and a direction to the project	
2nd-order theme: POSITIVE INTERPLAY BETWEEN SIMILAR UNDERSTANDING AND DISCUSSING	**SYNCHRONOUS DISCUSSIONS**
1. We two were able to support each other because of having a similar understanding	
1. One can comment or give feedback when there is an overlap of expertise	
1. Discussing the intricate concept with this one person who understands the linkages and interdependencies	
1. On group calls people can ask what they don't understand, and others can clarify, e.g., their slides	
1. In discussions linkages have been found between different fields. One person's problem is found not to be a problem at all by another person, instead it is found to be something that is needed	
1. Finding a similar understanding or similar thoughts through discussions	
1. Discussions at certain points summed up the progression	
2nd-order theme: MORE TIME TO ELABORATE IN PRIVATE DISCUSSIONS	**SYNCHRONOUS DISCUSSIONS**
1. We had a bit more time and definitely got to sketch out that subject a bit more in a two-person discussion	
1. In brainstorming sessions we had enough time to just sit down and do some drawings	
1. In a group discussion you try to limit your answers not to take up a too large proportion of the hour	
1. Focusing on a certain part of the concept, or closely related topics, in mini-group discussions	
1. Along one-to-one discussions one goes deeper into things, and also new things may come to mind	

2nd-order theme: CONCEPTUAL DESIGN ARTIFACT	**DUAL STATUS OF STRUCTURING AND COMPILING**
1. We discussed presentation draft in meetings, and then made new posts with more detailed information	
1. PowerPoint slides formed the tracking of our current thoughts and the project as a whole	
1. Each of us made comments on PowerPoint presentation, and always new integrated versions were discussed in the meetings	
1. The triangle helped the group to structure ideas	
1. Slides showed the whole structure and parts that need to be filled	
1. Slides facilitated knowledge sharing as one instantly understood what type of knowledge is missing, and contribute there	
1. PowerPoint slides had focus areas and parts for each of us to fill in	
VIRTUAL PROJECT PLATFORM	AGGREGATE DIMENSIONS
2nd-order theme: MAJOR SCENE OF THE PROJECT	**BASIC SOCIOMATERIAL SUPPORT**
1. The platform kind of keeps the project together without noticing	
1. The platform allows team members to share files and comment	
1. Ideation and knowledge sharing takes place mostly on the platform	
2nd-order theme: OPEN SHARING	**BASIC SOCIOMATERIAL SUPPORT**
1. The benefit of the platform is that people can throw there whatever ideas	
1. On the platform you can send some information FYI, or feel pretty comfortable to send any idea	
2nd-order theme: OCCASIONAL CHALLENGES IN FINDING AND PROCESSING WITH KNOWLEDGE	**BASIC SOCIOMATERIAL SUPPORT**
1. Sometimes finding new comments and following discussions is difficult	
1. Not being able to make comments directly on the files is challenging	
1. It is easier and faster to get briefed on when speaking compared to scrolling the knowledge on the platform	
1. Finding a certain comment, a link, or a material is slightly challenging when the project progresses	

2nd-order theme: ASYNCHRONOUS COMMUNICATION WITH OCCASIONAL DELAYS	**BASIC SOCIOMATERIAL SUPPORT**
1. You follow discussions and comment on them when you have a free moment on your calendar	
1. When you know the cyclical rhythm you can relax even when there are a few silent days	
1. Reaching a person on time with a platform message is uncertain	
1. On the platform the discussing rhythm is cyclical, comments can follow after days	
1. I can work on the ideas in privacy and share on the platform when it's the best moment for me	
2nd-order theme: A LACK OF INTERACTIVE AND FOCUSED DIALOGUE	**BASIC SOCIOMATERIAL SUPPORT**
1. The platform is quite straightforward and does not well support fast reacting and dialogic discussions	
1. Phone discussions are more interactive than platform discussions	
1. One does not easily comment earlier discussions on the platform	
1. On the platform ideas are rather shortly commented than discussed or enriched as in virtual meetings	
1. More focused discussion is easier on the phone	
1. Getting everyone's viewpoints, and then evaluating and deciding the focus, is easier on phone	
1. Cross-commenting in meetings was quite good	
1. A greater brainstorm experience happens outside the platform	

Appendix 6 Data structure: Project leaders and experts (case data)

PROJECT LEADERS	AGGREGATE DIMENSIONS
2nd-order theme: COORDINATING AND LEADING THE PROJECT	**TAKING RESPONSIBILITY**
1. We coordinate the whole project and respond to the client	
1. The role of project leaders was visible and very clear	
1. The role of project leader is significant in bringing the project forward	
1. She takes care of things considering the team, and I am contact person to the client	
1. I have done plans and schedules, handled things related to project management	
2nd-order theme: INTEGRATING KNOWLEDGE AND MAKING FINAL DECISIONS	**TAKING RESPONSIBILITY**
1. Project leaders work on the final report at this ending phase	
1. Project leaders have the responsibility to make the final decisions	
1. Project leaders have the challenge to integrate all knowledge	
1. Project leaders have a lot of responsibility for integrating at the end	
1. In this finalizing phase Anne and I will do the decisions together	
1. After the next phone meeting we will take care of the rest	
2nd-order theme: ENCOURAGING AND ACTIVATING EXPERTS	
1. We encouraged experts to discuss on the platform and tried to get everyone participating	**FACILITATING KNOWLEDGE CO-CREATION**
1. Project leaders pushed people forward so things progressed	
2nd-order theme: COMMUNICATING KNOWLEDGE ACTIVELY	
1. We took an approach to agree weekly meetings with the team from the start	**FACILITATING KNOWLEDGE CO-CREATION**
1. Transferring knowledge from the client to the experts	
1. They all the time kept in touch with me, and I felt the project was under control	
1. Communication has went well but it needs very active approach from project leaders	
1. One expert could not attend on weekly meeting so we agreed a separate meeting with this person	
2nd-order theme: COLLECTING VIEWPOINTS OF INDIVIDUALS	
1. We shared the idea and asked opinion of others	**FACILITATING KNOWLEDGE CO-CREATION**
1. Utilizing the expertise by pointing out the knowledgeable experts and asking their opinions	
1. Project leaders did a pretty good job by collecting everyone's viewpoints	
1. Everyone represents own viewpoint, project leaders probably have the best view of the whole	

EXPERTS	AGGREGATE DIMENSIONS
2nd-order theme: TEXTUALIZATION OF INDIVIDUAL KNOWLEDGE	
1. It is nice to write down the ideas that have been in my mind for many months	**EXPERTS AS KNOWLEDGE RESOURCES**
1. I already had the knowledge but needed to write down for this project	
2nd-order theme: DIVERSE EXPERTISE AND COMPLEMENTARY KNOWLEDGE	
1. We all had different knowledge and specialties	**EXPERTS AS KNOWLEDGE RESOURCES**
1. There are lots of different overlapping areas of expertise	
1. My and one team member's knowledge, ideas and experience were different but complementary	
1. It's really nice to have different experts, some with really high specific understanding of their sections	
2nd-order theme: ACCESS TO VALUABLE SOURCES OF INFORMATION	
1. There is much know-how and reference cases in Holland, and we got a lot of insight from our Dutch contact	
1. The more one does this, and follows happenings in the industry, the more ideas get enriched and can be combined to these projects	**EXPERTS AS KNOWLEDGE RESOURCES**
1. One would not have found alone all the knowledge that came from different angles, from experts with different backgrounds	
1. He has given some international benchmarking to our ideas	
1. Benchmarking knowledge to ideas and viewpoints was received from the Dutch expert	
2nd-order theme: WAITING FOR CLEARER INSTRUCTIONS	**FACTOR IMPEDING PARTICIPATION**
1. It was unclear whether I was supposed to add something on the PowerPoint, or not	
1. I did not ponder what to do but rather waited for being contacted and given orders	
2nd-order theme: NOT SEEING OR KNOWING PEOPLE	**FACTOR IMPEDING PARTICIPATION**
1. I feel that not knowing the people slightly slows down knowledge sharing	
1. In virtual meetings I sometimes was not sure whether others were listening to me, or doing something else, when they did not comment	
2nd-order theme: DIFFICULTIES IN FOLLOWING OR UNDERSTANDING	**FACTOR IMPEDING PARTICIPATION**
1. Someone was not fully communicating or being understood after missing a meeting or two	
1. I was not able to comment because of the level of detail of the knowledge	
1. For me understanding was difficult because of the language and the sound quality	
1. I think that it was not my expertise so I don’t necessarily need to understand it as long as I bring my own perspective to the project	

Appendix 7 Data structure: Facilitation during the process (individual interviews and focus groups of project leaders)

NEED FOR FACILITATION DURING THE PROCESS	AGGREGATE DIMENSIONS
2nd-order theme: SHARED COMMUNICATION PRACTICES	**SUPPORTING EFFICIENCY AND EFFECTIVENESS**
1. Sometimes there are days between comments so ideas cannot be developed, I recommend shared working times on the platform	
1. One should summarize the main idea, and not just share a link without explaining the reason	
1. There have been both extremes; being afraid to share silly ideas and brainstorm on the platform, and sharing all kinds of links, not really knowing what to do with all the data	
1. Marking comments with a hashtag is a brialliant idea, but it has not functioned in practice because people have not remembered to do it	
1. It does not work so that people post long research reports and expect someone to have time to read hundreds of pages	
2nd-order theme: ADAPTABLE KNOWLEDGE STRUCTURE	**SUPPORTING EFFICIENCY AND EFFECTIVENESS**
1. Nobody was able to put those brilliant ideas into a written format or the final presentation	
1. It is not good to have too strict structure to be able to do some needed changes	
1. At the beginning of the next project I would probably create some framework with categories what is related to what, actually the headlines of the final document	
2nd-order theme: FACE-TO-FACE MEETING	**CREATING SOCIAL CONDITIONS FOR CO-CREATION**
1. We might have needed a face-to-face meeting, it is easier to discuss with people you have met	
1. Working on the platform is much easier once you have met the people, face-to-face meeting at the beginning is very important	
1. Occasionally it is good to meet, one easily misunderstands the tone of a written text	
1. It was good that we met with the whole crew at the beginning, discussion is nicer also on the platform after you have met the people	
1. Combination of virtual and face-to-face working is quite good	

2nd-order theme: TAKING CARE OF FOCUS AND PROGRESS	**SUPPORTING EFFICIENCY AND EFFECTIVENESS**
1. It is not efficient to have more than a few people developing ideas	
1. Ideation gets easily extended too much, project leader needs to delimit the scope to keep it doable	
1. Ideation phase can continue forever unless it is stopped	
1. Towards the end, and actually getting the project to end, it is important to start focusing the discussion	
1. It was an ideal project with short ideation, pulling it together, delivering to a client, and that's it	
2nd-order theme: KNOWING WITH WHOM ONE IS WORKING WITH	**CREATING SOCIAL CONDITIONS FOR CO-CREATION**
1. It is remarkably more difficult to begin to ideate or co-create with people who are completely unknown to you	
1. People should know who are in the project, why, and what their areas of responsibility are	
1. As facilitator I try to get everyone familiar with each other and comfortable with the project	
FACILITATIVE ACTIONS OF PROJECT LEADERS	AGGREGATE DIMENSIONS
2nd-order theme: ACTIVATING AND GUIDING DISCUSSIONS	**SUPPORTING EFFICIENCY AND EFFECTIVENESS**
1. I guided people to discuss on the platform	
1. I tried to activate the discussion by commenting, and by asking questions and opinions	
1. The key role is to activate the client to join, and also those experts who might be passing	
1. Later I start gently pushing experts to actually contribute, to make decisions, and to sort of refine the discussion further	
1. Sometimes I threw wild ideas to open up discussion	
1. He activated by saying in advance who gets a turn to reply or to speak next and after that	
1. Activating experts is often the most efficient and meaningful when you can offer an incentive, and remind them what we are doing and why	
1. I think running the co-creation session is maybe the most demanding task that a Project Manager has	
1. More direct guiding that this is the concept, now lets comment this, don't share anymore new ideas, or bring them directly to the concept, not as a link	

2nd-order theme: COMMUNICATING EXPECTATIONS CONSTANTLY	**ALIGNING EMERGING IDEAS WITH PROJECT OBJECTIVES**
1. I have reminded experts about the goal and the changing priorities	
1. In the email I said that the upcoming meeting is not for chatting but for developing the concept proposals further	
1. She took the team to a like a wrap-up session every week or every second week, to go through platform writings and how to continue	
1. Setting the expectations during the co-creation session keeps people active	
1. Communicating expectations at the beginning; what input and in which format is wanted	
1. People have participated more actively when they are encouraged with a personal message, and they understand that something is expected from them	
1. I think the experience of being personally involved or personally asked to contribute makes people participate more actively in virtual co-	
2nd-order theme: CREATING A FRAMEWORK TO STRUCTURE IDEAS	**SUPPORTING EFFICIENCY AND EFFECTIVENESS**
1. I have pulled things together, summarized material, and divided ideas to have a framework	
1. Sooner or later I have integrated all the ideas under headlines and told what they are about, which makes further commenting easier	
1. We made the table of contents of the final report, and now we get directly content there	
2nd-order theme: CREATING A POSITIVE AND COMPELLING ATMOSPHERE	**CREATING SOCIAL CONDITIONS FOR CO-CREATION**
1. In the beginning it is important to get everyone in a positive vibe	
1. The challenge is to keep people's interests in the project, and secure that they are available when needed	
1. After the ideation phase there is a moment when the level of participation drops for a moment	
1. You can lead top experts only by asking nicely and trying to activate them	
1. When there are real experts in the team it makes you feel silly unless you also bring valuable things on the table	
1. It can really be a great challenge if the team does not actively contribute and participate	
2nd-order theme: APPRAISING EMERGING IDEAS	**ALIGNING EMERGING IDEAS WITH PROJECT OBJECTIVES**
1. I think it's important to prioritize the ideas and proposals, which are eventually communicated to the customer	
1. There are great ideas but you need to understand whether they are realistic in this context	
1. You need to analyze the discussion and conclude it, and then ask the right questions	
1. I go to present to the client the solution alternatives, and then we should analyze them further	

Appendix 8 Data structure: Support in virtual project environment (individual interviews and focus groups of project leaders)

SUPPORT IN VIRTUAL PROJECT ENVIRONMENT (SOLVED)	AGGREGATE DIMENSIONS
2nd-order theme: KNOWING THE COMPETENCE OF EXPERTS	**APPROPRIATE ASSESSMENT OF FINANCIAL AND KNOWLEDGE RESOURCES**
1. In addition to areas of expertise, it would be important to know what other skills and strengths people have	
1. Profile information with strengths and skills would help to build up an ideal team, and delegate tasks	
1. One could give feedback to experts who have been involved in projects, as a quality assurance	
1. I don't know which experts to ask to join, who are right now active, and what real competence each has	
2nd-order theme: SUPPORTIVE FUNCTIONALITY OF THE PLATFORM	**PROCEDURAL SUPPORT**
1. It is a very good discussion platform, but to be a co-creation platform it should allow categorizing and voting on ideas	
1. You can brainstorm on the platform, but to be a project tool it should allow task allocation, and navigate you through the process	
1. It would make the whole thing easier to be able to work with one version of the document on the platform	
2nd-order theme: CLARITY IN WORKING MODEL AND PROCESS	**PROCEDURAL SUPPORT**
1. Co-creation process is challenging and insecure, you don't know the exact end result at the beginning	
1. The working model and the whole process, how to begin and end a project, could be clearer	
1. A fuzzy beginning with no clear project plan or task allocation is problematic	
1. It's challenging to describe what the iterative process and design thinking means	
1. It's a problem that I don't know whether I am the project leader, the roles and tasks are unclear	
2nd-order theme: ADMINISTRATIONAL SUPPORT	**PROCEDURAL SUPPORT**
1. There should be some common documents, tools and guidelines for project leaders to apply	
1. It has felt laborious to explain the whole thing many times to new people who have come along	
1. There should be reporting of working hours so that project leader knows the situation of resources	
2nd-order theme: INTER-PROJECT, PEER-TO-PEER LEARNING	**SOCIAL INTERACTION WITHIN THE NETWORK AND LOCAL COMMUNITIES**
1. On the platform there could be a group or a spot where to tell about projects and share best practices	
1. There could be a face-to-face meeting once or a couple of times a year for project presentations and deeper peer-to-peer learning	

2nd-order theme: ALIGNMENT OF CONTRIBUTIONS AND COMPENSATIONS WITH PROJECT OBJECTIVES

APPROPRIATE ASSESSMENT OF FINANCIAL AND KNOWLEDGE RESOURCES

1. In one project there was a high-level expert who pretty much gave a standard answer because there was no time to become familiar with the project
1. In every project I have used remarkably more hours than what has been budgeted
1. It is very important to consider at the beginning the expertise needed, so that compensations would be in line with contributions
1. Budget is decided, in what time the report has to be ready and what to include, task descriptions have to be determined already before the co-creation phase
1. It was difficult to push people to do things as I did not know what had been paid to whom

2nd-order theme: GETTING TO KNOW ONE ANOTHER

SOCIAL INTERACTION WITHIN THE NETWORK AND LOCAL COMMUNITIES

1. The most important thing would be to somehow enable people to get to know each other
1. For me it has been a bit challenging to work with people I have never worked before, and do not know at all
1. It can feel a bit dangerous to take an expert you don't know
1. A certain kind of element is missing when you work with people you don't know at all, and depend solely on online comments
1. I don't want to share all my knowledge with everyone, especially with people I don't know