Hannele Lampela

INTER-ORGANIZATIONAL LEARNING WITHIN AND BY INNOVATION NETWORKS

Supervisor   Docent, Professor Hannu Kärkkäinen
               Faculty of Technology Management
               Department of Industrial Management
               Lappeenranta University of Technology
               Finland

Reviewers   Professor Eila Järvenpää
               Faculty of Information and Natural Sciences
               Helsinki University of Technology
               Finland

               Professor Annick Castiaux
               Faculty of Economics, Social Sciences and Business Administration
               University of Namur
               Belgium

Opponent   Professor Annick Castiaux
               Faculty of Economics, Social Sciences and Business Administration
               University of Namur
               Belgium

ABSTRACT

The thesis deals with the phenomenon of learning between organizations in innovation networks that develop new products, services or processes. Inter-organizational learning is studied especially at the level of the network. The role of the network can be seen as twofold: either the network is a context for inter-organizational learning, if the learner is something else than the network (organization, group, individual), or the network itself is the learner.

Innovations are regarded as a primary source of competitiveness and renewal in organizations. Networking has become increasingly common particularly because of the possibility to extend the resource base of the organization through partnerships and to concentrate on core competencies. Especially in innovation activities, networks provide the possibility to answer the complex needs of the customers faster and to share the costs and risks of the development work. Networked innovation activities are often organized in practice as distributed virtual teams, either within one organization or as cross-organizational co-operation. The role of technology is considered in the research mainly as an enabling tool for collaboration and learning. Learning has been recognized as one important collaborative process in networks or as a motivation for networking. It is even more important in the innovation context as an enabler of renewal, since the essence of the innovation process is creating new knowledge, processes, products and services. The thesis aims at providing enhanced understanding about the inter-organizational learning phenomenon in and by innovation networks, especially concentrating on the network level. The perspectives used in the research are the theoretical viewpoints and concepts, challenges, and solutions for learning.

The methods used in the study are literature reviews and empirical research carried out with semi-structured interviews analyzed with qualitative content analysis. The empirical research concentrates on two different areas, firstly on the theoretical approaches to learning that are relevant to innovation networks, secondly on learning in virtual innovation teams. As a result, the research identifies insights and implications for learning in innovation networks from several viewpoints on organizational learning. Using multiple perspectives allows drawing a many-sided picture of the learning phenomenon that is valuable because of the versatility and complexity of situations and challenges of learning in the context of innovation and networks. The research results also show some of the challenges of learning and possible solutions for supporting especially network level learning.

Keywords: inter-organizational learning, network learning, learning challenges, innovation networks, innovation management
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LIST OF PUBLICATIONS AND AUTHOR'S CONTRIBUTION

The publications included in Part II of the thesis are listed below, with a description of the author's contribution in each publication. In Publication II, the order of authors is alphabetical because the evaluated contribution of the authors was seen equal.

Publication I

Lampela, Hannele & Kärkkäinen, Hannu (2008): "Systems Thinking and Learning in Innovation Process". *Int. J. Entrepreneurship and Innovation Management,* Vol. 8, No. 2, pp. 184-195.

The author has presented the first research plan, wrote the paper together with the co-writer, coordinated the writing and publication process, made the revisions and also presented an earlier version of the paper in the XV ISPIM Annual Conference, Oslo, Norway, June 20-23, 2004.

Publication II

Hallikas, Jukka, Kärkkäinen, Hannu & Lampela, Hannele (2009): "Learning in Networks: An Exploration from Innovation Perspective". *Int. J. Technology Management,* Vol. 45, No:s 3-4, pp. 229-243.

The author has presented the first research idea, participated actively in writing the paper, coordinated the writing and publication process as a contact author and also presented an earlier version of the paper in the XVI ISPIM Annual Conference, Porto, Portugal, June 19-22, 2005.

Publication III

Lampela, Hannele & Kärkkäinen, Hannu (2009): "Views and Practices on Inter-organizational Learning in Innovation Networks" *Int. J. Electronic Business*, Vol. 7, No. 2, pp.130–148.

The author has presented the first research idea, participated actively in writing the paper, coordinated the writing and publication process and also presented an earlier version of the paper in the ICEB+eBRF 2006 Conference, Global Conference on Emergent Business Phenomena in the Digital Economy, Tampere, Finland, November 28 - December 2, 2006.

Publication IV

Lampela, Hannele, Kuvaja, Matti, Kyrki, Anna, Kärkkäinen, Hannu & Piirainen, Kalle (2008): "Challenges and Practices for Learning within and by Innovation Networks". CD-publication, Proceedings of The XIX ISPIM Annual Conference: Open Innovation: Creating Products and Services through Collaboration, International Society for Professional Innovation Management, Tours, France, June 15-18, 2008.

The author has made the research plan, planned and conducted the interviews, analyzed the data together with other researchers, coordinated the writing process, wrote most of the paper, and presented the paper in the abovementioned conference.

Publication V

Stevens, Eric, Kärkkäinen, Hannu & Lampela, Hannele (2009): "Contribution of Virtual Teams to Learning and Knowledge Generation in Innovation-Related Projects". *Int. J. Product Development*, Vol. 8, No. 1, pp. 1–21.

The author has made the research plan with others, wrote her part of the paper, especially on the life-cycle model of virtual teams' learning and the learning challenges, coordinated the writing and publication process as a contact author and also presented an earlier version of the paper in The XVII ISPIM Annual Conference: Networks for Innovation, Athens, Greece, June 11-14, 2006.

Publication VI

Lampela, Hannele, Kärkkäinen, Hannu & Stevens, Eric (2008): "Effect of Virtual Teams for Learning in Innovation: Contributing and Inhibiting Factors". CD-publication, Proceedings of The 5th International Conference on Intellectual Capital, Knowledge Management & Organisational Learning, New York Institute of Technology, New York, USA, October 9-10, 2008.

The author has made the research plan with others, planned and conducted the interviews in Finland, analyzed the data, coordinated the writing process, and presented the paper in the abovementioned conference. A revised version of the paper has been submitted to *Knowledge Management Research and Practice* journal for review.

Part I

Overview of the Dissertation

1 Introduction

The first section of the thesis describes the background of the study, objectives and research questions and the motivation, scope and structure of the research.

1.1 Background

The current business environment emphasizes the need for a relatively new approach in management that originates from the resource-based view of organizations (see e.g. Penrose, 1959, Barney, 1991; Barney et al., 2001), namely the knowledge-based view (e.g. Grant, 1996; Grant, 2008, p. 159). From a resource-based viewpoint, an organization's competitive advantage is based on its ability to acquire, maintain and modify its physical, human and organizational resources and capabilities according to the environment (Barney, 1991; Barney et al., 2001). All critical and valuable resources for value creation need to be secured, whereas from a knowledge-based view the organizations can be seen as social communities that specialize in the creation and transfer of knowledge (Kogut & Zander, 1996) and managing the knowledge resources of an organization is the key to competitiveness. Because of the rising importance of knowledge in strategic management, knowledge management has fast become a wide-spread practice in organizations, leading to new kind of challenges for managers trying to cope with the intangible nature of knowledge (Soo et al., 2002; Grant, 2008). The practice and research field of industrial management are very broad and have been evolving over time, as new management perspectives have been incorporated in the current body of knowledge. The nature of industrial management research is often interdisciplinary, as in this thesis which concentrates on the areas of innovation management and knowledge management.

Organizations need to produce innovations to achieve and maintain competitiveness, and utilizing information and knowledge assets has become a must in innovation-based competition (Soo et al., 2002; Davenport & Harris, 2007). Innovations can be linked to competitiveness in many ways, depending on the type of innovation, but the measurement of innovation and its effect on performance is difficult (Tidd, 2001; Tidd et al., 2001). To produce innovations effectively, organizations need to operate in networks. Networking in organizations and especially in the area of innovations has increased due to several reasons. The complexity of products and services has increased because of the need to satisfy various customer requirements. This means for the organizations an integration of broad set of specialized skills, and complementary strengths are often sought from partners as each organization is concentrating on core competencies. Thus, networks are a natural organizational solution for innovation. Other reasons for the increase of networking in innovation include leveraging the often high risks in innovation activities and possibilities to learn from partners, gaining access to new knowledge, resources or markets. In addition to these benefits identified by established network theories, in the literature a systemic view of networks has recently introduced the possibility of emergent properties of networks, meaning that the network is more than the sum of individual organizations (Calia et al., 2007; Tidd et al., 2001, 28-30).

In several sources, recent literature has identified learning as an important process for innovation both conceptually and empirically (Alegre & Chiva, 2008). The role of inter-organizational learning as a way to secure innovativeness, knowledge and various competencies needed for innovation, and avoid competency traps is growing, as organizations realize that they need co-operation and networks to successfully produce innovations. Collaboration between multiple partners requires especially network level learning, where the network partners are learning together as a network, rather than as individual organizations. Already more than a decade ago, Bierly & Hämäläinen (1995) concluded based on Teece (1992) and Gugler (1992) that: "Overall, the rapid increase in the number of joint-ventures, R&D consortia, and strategic alliances in technology intensive industries is a clear sign of the growing importance of network learning for organizational competitiveness."

In a study of learning and network collaboration in product development, looking from the perspective of one innovative organization and its relationships, Miettinen et al. (2008) recognize the importance of boundary-crossing, learning and innovation for the strategies of the organization. In their study, the R&D process is seen as many intertwined dynamic processes where the product, the network relationships and the learning all develop simultaneously. On the strategic level, learning can be one of the success factors in creating the future of the organizations and networks (Miettinen et al., 2008; Calia et al., 2007). The learning capabilities of an organization or a network affect its innovation activities, and innovation is perceived in essence to be a learning process (McKee, 1992). Learning is strongly linked to competitiveness through innovation and renewal. From a strategic point of view, one could say that the learning capabilities of an organization enable its renewal, proactive anticipation of future strategies and also a more sustainable competitive advantage. Also on the network level, learning can increase competitiveness when the competition increasingly takes place between networks, not between individual organizations. The possible positive link of learning to strategy and success in organizations is, however, only one side of the coin. On the other side are the threats that it poses through losing valuable knowledge, as well as the possibility of learning wrong things. Thus the phenomenon of learning itself is not positive or negative by nature, but the results and context of the learning affect this (Crossan et al., 1995).

1.2 Research objectives and questions

As the significance of innovation, learning and networks has increased in all kinds of organizations, so has also the research on these areas multiplied in recent years. However, these research areas have not been combined in many studies. The final *purpose* of this research is to improve the competitiveness of innovation networks through support for learning. This is based on the assumption that the possibilities that learning provides for the networks are not recognized and utilized to their full potential in the current practices of organizations and innovation networks.

The *main objective* of the research is to increase the understanding on the phenomenon of inter-organizational learning in the innovation network context by combining the perspectives of learning, networks and innovation. The focus is on the viewpoints and concepts, challenges and solutions related to learning especially on the network level. This is formulated into the following *research questions*:

- What are interesting viewpoints and concepts on organizational learning that can provide insights for networked innovation?
- What kind of challenges related to learning in and by inter-organizational innovation networks can be identified?
- What kind of organizational solutions, processes and practices, and technical systems can enable and support learning in and by innovation networks?

In this research, the viewpoints or approaches to learning are broad explanations or theoretical models found in the learning literature, whereas the concepts refer to specific terms or other constructs used within an approach. For example, systems thinking is an approach or viewpoint that includes the concept of double loop learning. This will be explained in more detail in section 3 of the thesis.

1.3 Motivation

Although the area of organizational learning is widely researched, the research remains scattered as noted by Fiol & Lyles (1985), and this notion was confirmed a decade later by Easterby-Smith (1997) and after twenty years to still be so by Shipton (2006). Often in the organizational learning research, the actual process of learning remains a "black box", and researchers generally link learning with a positive transformation (Crossan & Berdrow, 2003). Easterby-Smith (1997) has studied organizational learning research in relation to several disciplines, of which the management science and strategy perspectives are the ones utilized in this thesis. Easterby-Smith et al. (2000) have also identified future directions for organizational learning research, and have said that for example concrete practices for learning, and learning in large networks and alliances are some areas where they expect the research to grow.

Because of the growing importance of inter-organizational co-operation, also inter-organizational learning research has become more popular. Network learning, defined as learning that takes place between multiple partners as a group, has been scarcely researched, as most of the recent inter-organizational learning research actually deals with learning that takes place between two organizations, in a dyadic relationship. (Knight, 2002).

There seems to be a gap in the existing learning research, since especially when combining the network level learning to an innovation context, the existing research is very thin, although the importance of learning for innovation and networks has been recognized. A more detailed positioning of this research to the existing knowledge on inter-organizational and network learning in innovation context is done in section 3 of the thesis.

Researchers' personal motivations for research include for example learning, personal development, and research as a means to solve practical problems encountered (Easterby-Smith et al., 2008). A personal motivator for this research has been the earlier research work carried out by the management of technology (MOT) research team at Lappeenranta University of Technology; I have benefited from the team's and my supervisor's and also other collaborators' experience. Especially the practical experience on working in virtual research teams during the dissertation process has been valuable.

In addition, this study has been motivated mainly by problems recognized in today's organizational practices: the operating environment and forms of operating are changing faster than before, but the practices that fit the new situation are only slowly emerging. In the organizations, the importance of learning has possibly been noticed on the organizational level, but not so much on the network level. The organizations are getting used to operating in networks and managing them, but to ensure effectiveness and performance of the inter-organizational collaboration, they should also concentrate on the learning aspects and learning-related practices in the network, since in the changing environment the creation of general network management practices is not enough to secure renewal and competitiveness. According to Knight and Pye (2005), an integrative network perspective of organizations and businesses is needed to manage the complex and uncertain tasks in a changing environment, and facilitating learning is a key aspect in this.

Inter-organizational learning in innovation networks is a broad research topic covering a wide range of possible interests. This research concentrates on learning in inter-organizational networks in the context of innovation. The theoretical background of the research is based on knowledge management, innovation management, as well as organizational learning literature, specifically concentrating on inter-organizational learning and networks. Knowledge management is in this study seen from the point of view of dynamic processes and organizational activities, not only as managing intellectual capital as a set of knowledge assets in an organization.

The research aims to combine different perspectives on the areas of networks, innovation and learning and thus to increase understanding on inter-organizational learning in organizational networks, specifically innovation networks (see Figure 1 below). It does this on multiple levels: firstly by looking at the existing theories of organizational learning on a conceptual level increasing understanding on the subject, secondly bringing new knowledge on the challenges of especially inter-organizational and network learning from multiple perspectives, and thirdly also looking at possible solutions for the challenges and possibilities to support learning in innovation networks. In the solutions part, the focus is on for example virtual teams as an organizational form, and their tools as possible technical solutions for learning challenges, which were recognized as an increasingly relevant topic in the course of the research for several reasons: virtual teams are often a solution for organizing networked innovation in practice, and the challenges and solutions in learning are similar to inter-organizational networks even in internal virtual teams.

This research relates to the discussion of organizational, inter-organizational and network learning, and innovation within a network. All the three areas have previously been studied in the literature quite exhaustively as independent areas of study, and even as combinations of two out of the three, but the combination of all the three areas together has not yet been a research focus of wide interest. The importance of innovations for the success of an organization has been widely studied in recent years. Also the meaning of co-operation networks and learning for successful innovations has been discussed in some extent. Networks of partners are increasingly common in developing innovations, and they are perceived as a complex form of operation. Learning in networks has been studied from several viewpoints, but not so much in connection with innovation process. Also, learning by the network as a group, when the whole network is considered as the learner, is a novel topic for research.

From the learning point of view, the motivation for this study consists of the following: although the importance of learning for innovations as well as learning as an important collaborative process in networks have been established, learning has not been studied much in an innovation network context. From the innovation point of view, networks as a form of organizing have been studied widely, but the processes of learning especially on the network level are less known. From the network point of view, both innovation and learning have been studied as separate areas in network research, but the combination of the three provides new insights and a more detailed picture of learning in a specific network environment, innovation networks. All these aspects should be researched together, because the innovation context is especially challenging for learning due to several factors, such as information intensity and dynamic and complex nature of innovation, which are explained later in sections 2 and 3 of the thesis.

Although organizations are increasingly using co-operation networks in their innovation activities, practical examples and tools to support learning in this setting have been introduced only scarcely, and also the ways in which the learning occurs and how can it be better supported need to be clarified. Concrete examples of inter-organizational learning in practice include for example the changes in processes, routines and shared activities of the partner organizations that affect some part or all the network members. This research looks at inter-organizational learning both within and by networks in the context of innovation networks and concentrates on learning in and by innovation networks between different organizations.

Theoretical views and concepts

Challenges

Solutions
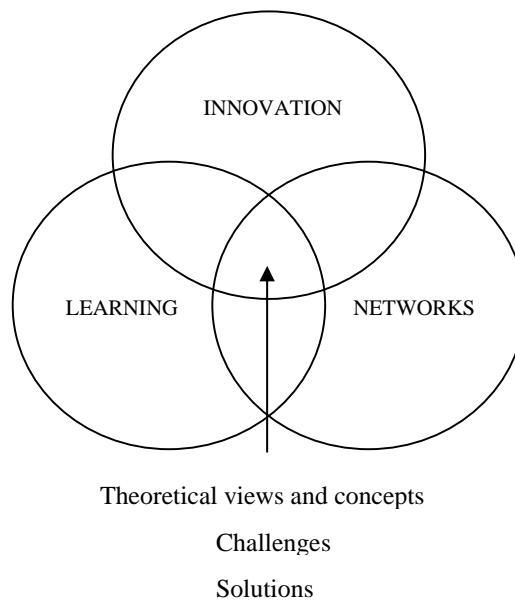
Figure 1. The domain, focus area and perspectives of the research

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The central focus of the study, as shown in Figure 1, is on the intersection of three domains; learning, innovation and networks; these will be discussed in more detail in sections 2 and 3 of the thesis. From this focus area, three interesting perspectives have been identified to form the research questions of the thesis. These are the theoretical views and concepts of learning relevant for innovation and networks, the challenges of learning and solutions for supporting learning.

All the three elements; networks, learning and innovations, have been suggested in the previous literature to be linked to competitiveness of organizations as independent elements or maybe through some combinations of two areas. This research extends the view to look at all the three elements simultaneously by studying especially network-level learning in innovation networks, which is seen as a possible source for network competitiveness. The research undertaken here is partly a network study, in the sense that it tries to answer questions of network management, and an innovation study, since the particular environment studied is the innovation networks and the complexities of innovation activities. Primarily, however, this is a learning study, since learning is the phenomenon at the focus of the research and the background used in the study relies mostly on organizational and inter-organizational learning theories.

1.4 Scope and structure of the research

In this section, a description of the research area and the level of study are given, to offer a more focused picture of the research and its limitations. The research gap and focus are further refined in the literature overview of sections 2 and 3.

1.4.1 Assumptions and limits

As discussed, the main objective of the thesis is to increase understanding on inter-organizational learning in innovation networks, concentrating on the network level learning. The wider purpose of this study is to increase the competitiveness of innovation networks through learning, as the meaning of learning for the long-term success of organizations is emphasized in several studies.

As a starting point, there are some basic assumptions and limitations, such as innovations are born increasingly in networks, and in an open, global and often distributed innovation environment, in networks of co-operation rather than within single organizations. Another starting point is that this research mainly looks at learning from the network level, not just learning within one company in the network, but learning between partners as a network. This includes also that the practices are not just copied from one partner to the other, but the partners develop something together that is new to both of them, and is shared between multiple members of the network.

The research view is partly based on systems thinking and a systemic view on learning (Checkland, 1981; Senge, 1990; Argyris & Schön, 1996). The networks of organizations are seen as learning systems within the context of innovation or product development processes. Innovation and product development activities are a complex field of operation, where

systemic view can help in seeing the bigger picture of the situation and understand the causes behind the actions (see e.g. Repenning, 2001; Repenning et al., 2001). Systems thinking has also affected the methodological approach of the research: the aim is to understand and form a rich picture of the learning phenomenon by bringing together different perspectives of the current theories on organizational and inter-organizational learning, rather than analyzing the phenomenon in detail by dividing it to smaller parts.

Assumptions on learning

In this study, learning and competitiveness is discussed mainly on the inter-organizational or network level, partly also at the level of participating organizations and the teams within them on the group level, but individual level learning has been left out since the individual learning processes have been discussed widely for example in psychology and cognitive science. Learning is not only restricted to specific learning events such as distance learning, e-training or distributed meetings supported by technology, but rather the aim is to look at distributed innovation activities and how the learning is manifested as part of all the daily operations.

Effective learning is understood in this study as an enabler of speed, flexibility and cost-efficiency of operations, not necessarily referring to measuring or evaluating the learning outcomes and the effectiveness of the process itself. The currently rising requirement for cost efficiency in organizations further justifies the increasing use of virtual teams as an organizational form, and also their inclusion in this study because of their flexibility and cost efficiency. Both the benefits and limitations of virtual teams are discussed especially from learning point of view.

This research sees learning fundamentally as a change process, and the theories of change through which the process is approached are especially the evolutionary model of change and the life-cycle model (Van de Ven & Poole, 1995). Learning as a change process (e.g. Knight & Pye, 2004) and its effects on strategic renewal (e.g. Crossan & Berdrow, 2003) have been discussed extensively in prior research. In this study, the focus is on the learning process itself, not so much on the learning outcomes. The applied view of organizations is that organizations form entities that consist of the building blocks of organizational structure, processes and systems, which are interdependent and linked together by knowledge. Changes can be implemented in any of these areas, thus learning can have an effect on any one of these or even on all of these. The solutions proposed later in this study concentrate mainly on processes and practices on one hand, and on the technical systems and tools used on the other.

Assumptions on networks and innovations

Since the focus of the study is on inter-organizational learning, the study is limited to business-to-business networks with specified partners. The consumer markets and innovation co-operation with end-users, for example the new forms of crowdsourcing and open source-based development work, are not included in the study. In business-to-business markets, it is possible to build long relationships between partners, which allow learning on organizational and inter-organizational level. The complexities in product development especially in

business-to-business markets are difficult to manage without procedures, tools and techniques (Kärkkäinen, 2002), which also emphasizes this focus.

Also, the study is limited to formal co-operation between partners that is usually regulated with agreements, or to internal networks within an organization, such as virtual teams, which can be seen as a specific form of networking in innovation. The inclusion of also internal virtual teams is based on the assumption that there are similar kinds of challenges in learning as in inter-organizational learning, although the teams would operate within the same company. They are regarded as organizations within organizations. The assumption made here is that the dominant factor affecting the challenges of learning and practices to solve them is the distance, not only formal organizational borders. However, the research setting is not comparative, since the primary aim of including the virtual teams has been to present a wide variety of viewpoints to the research topic.

In this research, the focus is on organizational networks which have well-defined, goal-oriented co-operation. Another type of networks that has not been included in the study is the "loose, wide networks" which typically do not require agreements and belonging to the network is more vague (Jarillo, 1998). The research looks at networks from an organizational level, thus another approach that includes the macro-environment such as national innovation networks is left outside the scope of this research.

The studied networks have a common goal to create something new, either a product, process or service innovation (Bessant et al., 2005) which is carried out in co-operation. Although the membership of the network is well defined, different partners might be involved in different stages of the development work, according to their specific roles. When talking about networks, the focus is on organizational level innovation networks, not on macroeconomic regional, national or international structures (Gilsing, 2005; Tödtling, 2009). This means that in many cases, the organizations involved in the empirical part of the study looked at the innovation network concept from a practical point of view related to their daily operations and equaled it with co-operation in R&D or product development functions. A recent area of study regarding networks is the social networks analysis (see application to knowledge management and innovation e.g. Parise, 2007). Although it might have had some interesting insights to offer, this approach has not been applied in this study. The aim is to look at the processes that take place within the network, not to study the network structure and its effects.

Innovation and innovation management are considered here as broad concepts including different types of processes and end results, such as new product, service, or process development (Tidd et al., 2001). Some articles included in the thesis highlight some aspects of innovations, especially product development, more than others. Other identified types of innovation introduced in the literature include for example organizational innovations (Lam, 2005) which are also discussed to some extent in the thesis under the theme of virtual teams, and business model innovations, which transform the operations of the organization and are a source for discontinuity (Bessant et al., 2005). Recently, as many as ten different types of innovation have been mentioned, depending on the sources.

1.4.2 Structure of the thesis

The thesis consists of an overview and six research publications in Part II of the thesis, which highlight versatile aspects of inter-organizational learning in innovation networks. The contribution of the research articles to the research areas and their links are introduced in the following Table 1 summarizing the study and positioning the articles:

Table 1. Positioning of the articles to the research areas

	Publication I	Publication II	Publication III	Publication IV	Publication V	Publication VI
Theoretical views and concepts of learning						
Challenges of learning						
Solutions / support for learning						

The idea of the research paper I is to give background from a systemic view on the complexities related to innovation activities and learning, especially learning challenges. On the conceptual level, it introduces single and double loop level learning and links these to innovation-related learning. It looks at learning challenges in innovation from systems thinking perspective. It highlights the importance of learning for innovation and the need for systems thinking as a possible solution for learning challenges. The following publications II and III identify on the conceptual level different approaches and perspectives on learning presented in the literature, which can be seen as relevant for innovation. Publication II discusses the challenges in inter-organizational learning in innovation context and proposes implications of the different learning approaches for networked innovation. Publication III combines the identified learning perspectives with a framework of learning types, and suggests practices for supporting learning from different theoretical perspectives. The practices for learning are also studied empirically in publication IV, which further describes inter-organizational learning in innovation networks and classifies the challenges of learning on different levels of learning, and provides empirical views on the practices for supporting learning.

The last two publications V and VI discuss on the conceptual level the role and potential of virtual teams as a practical way of organizing distributed innovation activities, develop a life-cycle model of virtual innovation teams from the learning perspective, and focus on the challenges and possibilities of virtual teams' learning, as well as virtual teams as an organizational solution for networked innovation. The two research streams of organizational learning views and virtual team learning have been combined in this study to bring both theoretical and practical understanding of the subject in innovation context, and to look at several levels of learning. In practice, virtual teams are often the organizational solution in distributed innovation activities. In these papers, the network view is not so much in the focus of the research, but the challenges and solutions of distributed working can be similar

to the inter-organizational environment. The virtuality of the working environment means more similar characteristics in learning than whether the working takes place with internal partners   in one organization or with external partners in other organizations.

2 Networking in Innovation

This section gives an overview of the literature related to the study from the point of view of innovation activities and networks, focusing on the concepts, challenges and solutions as identified by the research questions. The structure of the section also follows the logic of the research questions. The aim is to provide the reader with both conceptual definitions and further understanding on the focus and positioning of the research.

2.1 Defining innovation

Innovation has many varying definitions in the literature. This study uses a wide definition according to which innovation can be seen as "a process of turning opportunities into new ideas and putting these new ideas into widely used practice" (Tidd et al., 2001, p. 38). According to another similar definition, innovation is a novel invention which also has been commercialized (Miller & Morris, 1999).

One way of characterizing different types of innovations is their effect on the current thinking, practices and solutions, whether the innovations are considered to offer an incremental or radical change to the existing paradigm. The impact or degree of incrementality or radicality of the change can be assessed and reflected on multiple levels: novelty to the organization, novelty to the industry (Johannessen et al., 2001) or even novelty to the world. In this study, this classification is relevant when discussing different perspectives and practices of learning, since certain views of learning might be more useful to radical than incremental innovations. However, the distinction between incremental and radical innovation is not always so straightforward. In our empirical study, the radicality of produced innovations was not taken into account as it was not possible to assess it.

Innovations or development work, a new end product or a new way of doing or organizing can focus on several aspects in business such as the product, service, process or organization (Tidd et al., 2001). In this study, innovations are considered as a broad concept focusing on new product, service, or process development or their combination, including both the social and technical change. Innovation is seen as a broader concept than just product development, although in practice most of the development work in organizations concentrates on physical products. Also virtual teams are discussed in this thesis as a form of organizational innovation as they are recognized as a novel organizational form with special characteristics also in the literature. In practice, the competitive environment of the organization defines which types of innovations are preferred: process improvements, process innovations, product and service innovations, organizational innovations, business model innovations, radical or incremental innovations etc. (Koivuniemi, 2008).

Innovation management is defined as a complex process of managing information and knowledge inside the organization and in inter-organizational interfaces (Nonaka & Teece, 2001). Brown and Eisenhardt (1995) have recognized that innovation research has two broad categories: an economics-oriented tradition (focusing on patterns of innovation between countries and industry sectors rather than development processes in organizations) and an organization-oriented tradition, where a rich understanding of product development process

is presented. Johannessen et al. (2001) present four categories of innovation research: individual-, structure-, interactive-, and systems of innovation-oriented approaches. This study belongs to the organization-oriented tradition of research and concentrates on structure and interaction aspects, as it discusses for example the effects of organizational structure to learning in innovation context, and how interactions affect the structure and vice versa. In this study, the innovation networks are seen as a specific organizational structure, and virtual teams are also discussed as an organizational form. The process of learning is seen as an interaction process.

Literature on innovation management has introduced the idea of generations of innovation, which includes different ways to organize innovation activities and different focus in the development work. The successful organization of innovation is often complicated by the paradoxical nature and internal tension of the innovation process: requirements of present effectiveness vs. future flexibility, which both are relevant dimensions of innovation performance. Recent so-called 5th or 6th generation models of innovations are based on networking and collaboration between organizations, not only the activities of one organization individually (Tidd et al., 2001; Miller & Morris, 1999; Nobelius, 2004).

The way of organizing innovation and R&D has become a crucial question for management, and the development of R&D practices is a continuous task in organizations. There are several models or generations of R&D that have been developed over time, fitting different kind of contexts and highlighting different aspects in the development process:
- in the first generation, R&D focuses on breakthrough innovations and is isolated from the rest of the organization,
- the second generation sees R&D as a business guided by market pull,
- the third sees R&D as a portfolio of investments,
- the fourth integrates parallel, cross-functional activities to achieve speed, and finally
- the fifth generation focuses on R&D as a collaborative network with outside partners
(Miller & Morris, 1999; Nobelius, 2004)

The innovation process and its stages have been described with several different models over time, and the recent open innovation paradigm (Chesbrough, 2003) has introduced a new discussion on the topic by highlighting the importance of inter-organizational interaction through mutual exchange of ideas, technologies, knowledge and capabilities as sources of innovation. This paradigm shift towards a more open innovation process requires significant changes within organizations in organizing innovation as well as cognitive changes in management thinking. The notion of open innovation and the model of the open innovation process can be seen as a continuum of the above described development towards a more networked, open and collaborative form of producing innovations, which emphasizes the need for external, inter-organizational partnerships.

An organization's long-term competitive advantage and competitiveness is increasingly seen as dependent on its capability to innovate, to produce innovations to the market and to renew its operations (Miller & Morris, 1999, Tidd et al., 2001). Learning is a key process in innovation and renewal, and also it is seen as the source of sustainable competitive advantage (Slater & Narver, 1995; Nonaka & Teece; 2001). Networking is another source for competitiveness, as it enables for example increasingly complex end products to be

developed and organizations to focus on their core capabilities (Nooteboom, 1999). Participating in networks is a means for learning, and learning can be a very significant motive for networking especially in innovation. Learning on the network level enables also network competitiveness as we are moving from organization- or industry-based competitive environment towards more systemic structures of competition (business ecosystems) where the success of others affects everybody in the network (Moore, 1996). By utilizing networks to organize their innovation activities, organizations build on all of these aspects to secure competitiveness. The next sections will discuss networks and particularly innovation networks, the challenges they face and virtual innovation teams as a possible solution.

2.2 Defining networks

Just as the concept of innovation and the description of innovation process have evolved over time, also the understanding of an organization's relationship with its environment has developed. According to Allee (2003), organizations are evolving from value chain thinking originally presented by Porter (1985), where an organization participated to a value creating supply chain, to value networks, consisting of multiple partners on several levels co-creating value to customers. In these value networks, knowledge and learning play a very significant role as they are predominantly based on interactions other than traditional physical transactions, and value creation is based more on knowledge and information than physical products (Kothandraman & Wilson, 2001).

Research on business networks is very many-sided: there are several approaches and substantial literature (Möller & Rajala, 2007; Borgatti & Foster, 2003; Ritter & Gemünden, 2003). Networks have also been studied from the point of view of organizational and inter-organizational learning (Beeby & Booth, 2000), but the area of innovation networks and the phenomenon of learning in this context has not gained very much attention.

In the literature, the need and motivation for organizational networking has been explained through at least two perspectives; the transaction cost theory and the resource-based theory. Especially the resource-based theory emphasizes the role of collaboration and networks as a source for complementary resources, knowledge and learning, whereas in transaction cost theory the explanation for networking is built on achieving better efficiency and cost-savings through the network operations. Thus, the general reasons for co-operation and networking include for example the wider availability of resources and knowledge, concentration on core competencies, possibility for new knowledge creation and learning, access to new opportunities (markets, technologies etc.) product differentiation and innovation, economies of scale and scope or sharing costs and risks (see e.g. Nooteboom, 1999). In the case of innovation co-operation, especially the aspects of gaining new knowledge and sharing risks are often emphasized.

Organizational networks are becoming more and more common and complex, and their impact on business is manyfold. The development of co-operation has started with alliances which are first formed between two individual organizations that are willing to co-operate because of their complementary needs and capabilities. Strategic alliances have also been an important subject of study in for example strategic management and international business, where one of the widely researched forms of alliances has been joint ventures (Inkpen, 1998). Also organizational learning has been studied in strategic alliances and joint ventures,

and these are seen as a learning opportunity, utilizing the co-operation as access to the skills and capabilities of the partner (Inkpen & Crossan, 1995). Lubatkin et al. (2001) have studied different kinds of inter-firm alliances from the point of view of learning, and identified four types of learning alliances: vicarious learning alliances, knowledge absorption alliances, knowledge grafting M&A (mergers and acquisitions) and reciprocal learning alliances, which on the contrary to other alliance forms which focus on the transfer of existing knowledge, is based on co-learning, creating new knowledge and joint innovation. Recent organizational development and research has shifted the focus of inter-organizational research from dual one-to-one-relationships more towards co-operation networks with multiple participants (Borgatti & Foster, 2003).

Networks can be regarded as both the actor and the context, depending on the focus and analysis level. On the one hand, a network is an entity which can be analyzed independently and can be seen as an actor. On the other, a network always consists of smaller entities such as organizations in this study, and can be seen as a surrounding environment or a passive context to the interaction of the organizations. This view highlights the role of the individual organizations within the network, whereas the previous stance highlights the holistic, systemic nature of the network. The dual nature of the network concept also has implications to studying a network-related phenomenon, such as learning in this study, as shown later in the thesis in section 3. Learning is discussed both in the context of inter-organizational co-operation in general, and as network level learning specifically when the network is seen as the actor.

Networks can be classified into several types, depending on their purpose, strategic importance and focus. The purposes of networks can follow for example the functional structure of the organization: logistics (supply chain / distribution network), marketing (access network to markets and customers) or development activities (innovation network). One classification that is based on the idea of different value systems is presented by Möller & Rajala (2007, see Figure 2 below). In this typology, the strategic nets are divided into current business nets, business renewal nets and emerging business nets, in which innovation networks as defined in this study can represent all of these types depending on the innovation type (radicality of the change) and on the participants of the network. Note that the term "innovation networks" is used in the classification in a narrower meaning than in this study, as one of the emerging business nets, describing only networks that are based on science and research collaboration. Typically, current business nets are focusing more on the effectiveness of the current operations and changes are minimal or only incremental, when emerging business nets are the ones where new value systems are created and changes are radical and system-wide.

Current business nets		Business renewal nets		Emerging business nets		
Vertical demand-supply nets	Horizontal market nets	Business renewal nets	Customer solution nets	Application nets	Dominant design nets	Innovation Networks / Science and research networks

High level of determination   Low level of determination

Stable, well-defined value system	**Established value system, incremental improvements**	**Emerging value system, radical changes**
•Well-known and specified value activities •Well-known actors •Well-known technologies •Well-known business processes •Value system innovation, reconfiguration	•Well-known value systems •Change through local and incremental modifications within the existing value system •Incremental innovation: business processes, coordination, offering	•Emerging new value systems •Old and new actors •Radical changes in old value activities •Creation of new value activities •Uncertainty about both value activities and actors •Radical system-wide change • Radical innovation, discontinuous, transforming

Figure 2. Business net classification (modified from Möller & Rajala, 2007)

Networks as an organizational form have been divided in organizational research into intra-organizational networks, network organizations, strategic networks and more loosely bonded, wide networks (Knight, 2002). In this research, the main focus is on strategic, purposeful networks, although also intra-organizational networks are discussed in the form of virtual teams.

2.3 Innovation networks

As noted above, co-operation in the field of innovation is one of the areas of operation where the positive effects of networking can be realized. As customer requirements become more complex and the products have more complex features (Calia et al., 2007) and at the same time the domain of product development and innovation includes more uncertainties and risks than before, organizations seek for network partners to share the risks and to access various skills and resources that would not be available for it alone (e.g. Tether, 2002; Miotti & Sachwald, 2003). The globalization of markets and acceleration of technological progress particularly affect innovation co-operation. The pressure for faster time to market as well as sharing risks associated with new product development are also important reasons for co-operation. (e.g. Parker, 2000; Oxley & Sampson, 2004).

When a network is formed specifically for innovation purposes, the context of innovation brings several new aspects to the network operation compared to other types of organizational networks. In other types of networks concentrating on functions such as marketing or logistics, the primary motivation and objective of the co-operation is the possibility for cost-savings and economies of scale, or gaining access to markets and resources. An innovation network is characterized by its strategic importance for the competitiveness and success of the organization, and by the purpose of creating new ideas

(products, services, processes) and putting them into practice. The possibility for new knowledge creation and learning has a bigger role in forming and participating in innovation networks than in other kinds of networks. There is a need for high level of trust because of a great amount of sensitive information, and the importance of speed and flexibility of operating processes is emphasized at the same time with uncertainty, complexity and ambiguity related to the available information and operating environment. For example, the partners might have different views on the importance of the network and on the final objectives of the co-operation, which increases the confusion related to innovation co-operation. However, as the result of the co-operation and participating in an innovation network, an organization might be able to gain necessary resources to change its business model with new products and markets (Calia et al., 2007), and assume a larger role in the network than before.

A traditional supply chain or network concentrating on delivering end products to customers differs from an innovation network by having more stable and defined practices, and an operational rather than strategic focus. A supply network operates through predefined roles, and the purpose is to increase the effectiveness of the current operations, not necessarily to produce a new way of operating. Compared to an innovation network, a supply network is more a passive structure where organizations interact mainly through individual relationships, and development is not the main aim of the co-operation. An organization can have also co-operation focusing on product, process or service development with the partners in its supply network, but this differs from an innovation network because the development work is not the central focus of the co-operation.

2.4 Challenges in networked innovation

Co-operating in the field of innovation or product development is challenging due to many reasons, and especially when the complexity of the operations is increased by multiple actors in the network. Research and development activities are among the most knowledge intensive and challenging tasks in an organization (Eppler et al., 1999), and the global scope of product development brings another, cultural dimension of challenges. The effectiveness requirements on speed, flexibility and costs have a great influence on the organizing principles and operating processes of innovation. In studies on distributed global product development and innovation in general, the cultural and social challenges have been found as the most important (McDonough & Kahn, 1996). This includes issues such as knowledge sharing practices, communication, amount and quality of knowledge and information and trust, which are all further complicated by distance.

Other challenges that have been identified with networked development work are for example the integration of functions, establishing appropriate structures, organizing decentralized projects, use of ICT tools, managing the network and managing knowledge and human resources. These have been classified into six fundamental dilemmas that innovation management in a global organization should balance: local versus global, processes versus hierarchy, creativity versus discipline, control versus open source, face-to-face versus ICT and long-term versus short-term (von Zedtwidtz et al., 2004).

The early stages of collaboration are seen as the most critical for success, and the challenges that the companies face are mostly related to relationship and interaction issues such as trust,

personal chemistry and organizational culture. Managers tend to focus more on technical and legal issues than people-related issues, and as one solution to these challenges, a clear focus on learning and relationship building in the beginning of the co-operation has been suggested by Kelly et al. (2002). Weck (2006) has suggested increased attention to continuous learning as one success factor for collaborative research and development.

Learning can be seen as an especially relevant process particularly in innovation networks, because of the central role of knowledge in the process of creating new ideas (Tidd et al., 2001). It is also one of the most challenging topics related to innovation, because of the uncertainties and complexity inherent in innovation. Learning has been said to be even one of the possible sustainable basis for the competitive advantage of an organization (Slater & Narver, 1995; Nonaka & Teece, 2001), so the challenges in knowledge creation and learning have a profound effect also on the end results achieved by the network of organizations. The challenges related to learning in innovation will be discussed in more detail in section 3 of the thesis.

2.5 Organizing innovation virtually

One of the practical solutions in trying to overcome the challenges of global, networked innovation has been implementing virtual innovation teams. Virtual teams are becoming a standard way of organizing operations in many fields, especially distributed product development work (Hertel et al., 2005). Although virtual teams present many positive aspects such as possibility to use the competencies of the participants effectively, speed and flexibility, they also highlight the challenges related to distance. A virtual team is generally defined as a functioning team that relies on technology-mediated communication while crossing several boundaries, such as geographical, temporal, and organizational boundaries (Martins et al., 2004).

Virtual teams are emphasized in this study as one viewpoint as a flexible organizational form and because of the technical systems they use. They have been implemented increasingly in innovation and are a current topic for research because of the organizations' growing need to focus on costs and the flexibility of operations. Also, the competences needed for innovating new products, services and processes are increasingly distributed across organizations and continents. Virtual teams are also seen as an interesting area in this research because of the geographical location of Finland, which means that as a remote country with long internal distances the interest for virtual technology and organizational solutions is naturally high.

Virtuality can be seen as a characteristic of all organizations to some extent, and organizing operations virtually can be done at the level of a whole organization, not only virtual teams. It is a novel organizational form which also changes many of the current practices, tools and processes in organizations. In this study, virtual teams represent a practical example of organizing innovation activities, since it is a relatively new way of operating and practices and processes for effective virtual teams are currently emerging, as the available technology and tools develop. Through virtual teams, organizations aim at making their processes more effective in terms of speed, flexibility and costs, both internally and externally. However, there seems to be a lack of models and practices that would also consider the learning aspect of virtual teams and their management, and virtual teams have been only scarcely researched from the point of view of learning, especially connected to innovation.

The requirement for continuous learning and innovation, and the need to innovate rapidly leads to new organizational forms that are more flexible and often based on collaboration (Kosonen, 2008). In addition to this, the development of technical tools which enable efficient working across distance has promoted the use of virtual teams as an organizational and technical solution for organizing innovation. The growing importance of virtual collaboration is due to the improvement of the technical tools, which gives increased possibilities for real-time communication and collaboration across distance. Especially the recently developed so-called web 2.0 tools (wikis, blogs etc.) which are generally flexible, easier to access and enable interaction and support for simultaneous work better than previous systems (Kosonen, 2008), have contributed to the spreading of the virtual tools in the organizational use. The challenges of virtual innovation teams caused by distance and especially the challenges and possibilities they offer for learning are discussed in more detail in section 3.

3 Learning within and by Innovation Networks

In this section, the main areas of the research; innovation, networks and learning, are brought together as it discusses inter-organizational learning that takes place in innovation networks, at the levels of groups, organizations and the network itself. The individual level learning is left out of the study because of the significant amount of previous literature on this subject covered by different fields of research.

3.1 Inter-organizational learning and network learning

The following gives a brief overview of the basic concepts and classifications in the literature related to organizational, inter-organizational and network learning. First, the definition of learning in this study is discussed, followed by typical categorizations of learning in the literature based on the type, level and different theoretical approaches to learning. These definitions and categorizations are also utilized in various ways in the publications in part II of the thesis and in the empirical part of the study.

3.1.1 Types of learning

When discussing inter-organizational and network learning, the starting point is first to define what is organizational learning. In this research, it is assumed that organizations and other entities made up of individuals and groups are capable of learning and thus a valid unit of analysis. Organizational learning differs from individual learning although it is always based on individual learning (Crossan et al., 1995; Easterby-Smith, 1997). The learning entity, the learner can be also something else than the individual (group, organization, network). Another stream of research represented for example by Simon (1991), argues that only individuals have the cognitive abilities required for learning, so organizations learn only through individuals. However, if the concept of organizational learning is accepted, although it has variable definitions, it also has certain common characteristics:
- it is more than the sum of the individuals' learning
- it includes both cognitive processes and activities within organizations
  (Lundberg, 1995; Beeby & Booth, 2000)

Organizational learning is defined as acquisition of know-how, understanding, techniques and practices which are new to the organization, and as a result of this acquisition, the rules and processes, i.e. the behavior of the organization is changed (Argyris & Schön, 1996). Another view on learning argues that the change in actual behavior is not always necessary and learning happens also through a change in cognition, as Huber (1991) points out, that an organization learns, if the range of its potential behaviors is changed.

Descriptions of organizational learning in the literature can be divided into two broad categories focused on either the types of learning (single loop/double loop, cognitive/behavioral) or focused on the levels of organizational learning (individual, team, organization, relationship, network) which relate to the learning entity, the learner or to the context of learning. The existing literature on organizational learning is very extensive and has been growing significantly. The interest of the current thesis is to broaden the concepts

presented in organizational learning literature and focus on learning in inter-organizational context and especially on the network as a learner, which have only recently been acquiring more attention. Also, the learning phenomenon is not treated as a "black box" and as one unified process, but the aim is to present learning as a multidimensional, dynamic process through presenting many diverse descriptions and interpretations.

Traditionally, organizational learning has been discussed starting from the model of single and double loop learning presented by Argyris & Schön (1978). In this model presented in Figure 3 below, learning is seen as either changing the current behavior (single loop) or at the same time questioning and changing also the assumptions and values guiding the action on the background (double loop). The feedback loops are essential enablers of learning. From an innovation point of view feedback poses many challenges for learning, when the feedback is difficult to receive for example due to distance, number of actors, long delays between actions and other factors increasing complexity.

Single loop learning
Changing the current behavior

| Thought patterns and assumptions Variables guiding action (values, objectives) | Action models and strategies | Results and consequences |

Double loop learning
Changing the assumptions and values
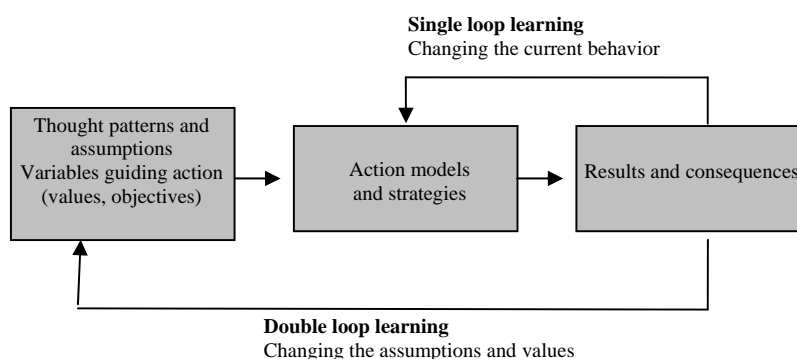
Figure 3. Single and double loop level learning (Argyris & Schön, 1978).

A widely cited writer on organizational learning and the structures and norms of a learning organization has been Senge (1990), who connected the ideas of organizational learning and learning organizations more firmly to strategic management and brought these learning concepts to wider practical awareness. An interesting note related to innovations is Senge's idea of the central role of systems thinking in enabling learning and development; he also highlights the importance of the individuals, particularly managers.

Another traditional classification of learning types concerns the effect of the change and its visibility, whether the learning affects the cognition, behavior or both. An example of the discussion about organizational learning as a change of cognition or behavior, and a more detailed framework developed from this idea, has been presented by Crossan (1991; Crossan et al., 1995; see Figure 4 below). In this framework, different types of learning have been classified from no change on either of the dimensions, resulting to no learning, to a change on both of the dimensions, leading to integrated learning. Between these, four types of learning can occur based on the situational factors and possibilities to implement the changes. The dynamics between the learning types can lead into a different end result than first observed. For example, when a change happens on the behavioral level and does not affect cognition (the forced learning type), the long-term effect might be no learning at all,

since organizations change back to their old routines and practices if no justification for the behavioral change is given. The types of learning have been further discussed in Publication III.
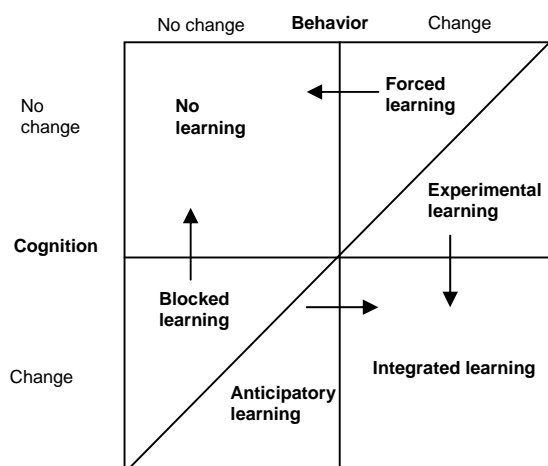
Figure 4. Cognition / behavior framework of organizational learning (Crossan et al., 1995; Crossan, 1991).

3.1.2 Levels of learning

The process of organizational learning has been further researched and illustrated by Crossan, Lane & White (1999) who present a so-called "4I-model" of organizational learning. In this model, the levels of learning are also included, so that the role of the learning entity is emphasized. The interest and focus of organizational learning research has been moving in recent years towards inter-organizational and network levels. The model of Crossan et al., (1999) has been extended later by Jones & Macpherson (2006) as shown in Figure 5, to cover also the inter-organizational level of learning (intertwining being the 5th I). Their study is limited to a dyadic relationship between two organizations, not on a network level, and they use data from a case of an SME as their empirical base. They recognize the value of interaction with external partners through for example customer requirements, supplier suggestions and direct links to knowledge providers, in institutionalizing learning. In this thesis, the interest is especially on the inter-organizational level and the processes related to intertwining; what does it mean in practice and how does it manifest between organizations, especially between multiple partners in networks. This has been studied in the empirical part of the research in Publication IV through identifying learning practices between organizations.

Individual   Group   Organization   Inter-organization

Feed forward learning flow

Individual
Intuition

Interpretation

Individual

Feedback learning flow

Group

Group

Integration

Organization

Organization
Institutionalization

Intertwining

Inter-organization

Inter-organization
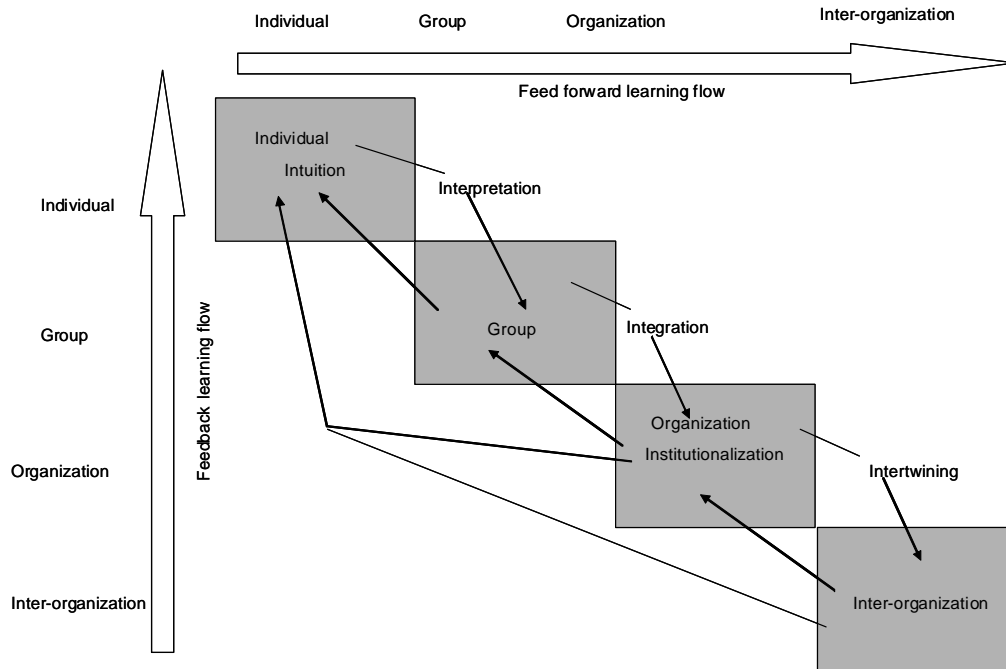
Figure 5. The 5I learning framework (Jones & Macpherson, 2006).

Inter-organizational learning is defined in this study as "learning in the context of groups or pairs of organizations" as presented by Knight (2002), where the network is seen only as a context for learning and the focus is on learning by the individual organizations. In the literature, the definitions and actual content of the term are variable, often describing any form of learning which originates from co-operation with external partners, but the focus is on the organization-level learning.

The difference of inter-organizational learning and network learning has been discussed by Knight (2002), who has created a two-dimensional matrix to identify inter-organizational learning by the level of the learner and the context of learning, in which both dimensions start from the individual and end to the network / inter-organizational level, as presented in Table 2 below. Network learning is defined as "learning by a group of organizations as a group" (Knight, 2002), thus it happens at the level of the whole network and affects all the involved organizations. It can be separated from other types of inter-organizational learning that happens in a network context, where the learning entity is something else than the network itself, e.g. individual organizations, groups or teams within organizations or even individual persons. The network can have two roles related to learning: it can be seen as an actor and as a context for learning.

Table 2. Level of learner / context of learning (Knight, 2002)

Context of learning → Level of learner ↓	Individual	Group	Organization	Dyad	Inter-organizational
Individual	Individual learns alone	Individual learns within a group	Individual learns within an organization	Individual learns within a dyad	Individual learns within a network
Group	Group learning is influenced by an individual	Group learns through intra-group interaction	Group learns within an organization	Group learns within a dyad	**Group learns within a network**
Organization	Organization's learning influenced by an individual	Organization's learning influenced by a group	Organization learns through intra-organization interaction	Organization learns within a dyad	**Organization learns within a network**
Dyad	Dyad's learning influenced by an individual	Dyad's learning influenced by a group	Dyad's learning influenced by an organization	Dyad learns through intra-dyad interaction	**Dyad learns within a network**
Network	Network's learning influenced by an individual	Network's learning influenced by a group	Network's learning influenced by an organization	Network's learning influenced by a dyad	**Network learns through intra-network interaction**

In the Table 2, the broad definition of inter-organizational learning as used by most of the current research covers the areas where the learner is the dyad or the network, or the context of learning is a dyad or inter-organizational. This has been highlighted by the grey background color in the table. Network learning which takes place at the level of the whole network is much more scarcely researched (Knight, 2002). Knight and Pye (2005) have also studied network learning in an empirical research, where network learning is characterized with changes in network-level properties: shared practices and processes. They analyzed network learning from the point of view of the context, content and process of learning, identifying the learning outcomes as changed practices, structures or interpretations.

In this research, the focus has been broadly in inter-organizational learning (the context of learning is inter-organizational), but it has evolved and sharpened during the research process towards more network level focus (the network as the learner), as more accurate classifications and definitions were available and the gap in especially network-level learning research was identified. The level of the individual as the learner has been left out although the context of the learning would be a dyad or inter-organizational, because of the vast amount of research already done in different fields concerning the individual learning process. Group learning and organizational learning within a dyad or within a network have been discussed in the thesis only briefly, the group level more in connection with the part of the research on virtual teams. Because the primary focus of the study has been on the inter-organizational context of learning and especially on the network as the learner, also the view

on dyads both as the learner, and as the context, is limited in this study. The focus areas of this thesis have been presented with bold text in the Table 2 above.

3.1.3 Different views on learning

Many diverse views on organizational learning have been presented over time, emphasizing different issues and concepts. This research studies six divergent theoretical views in more detail in the publications II, III and IV included in the thesis. These approaches have been selected considering their relevancy for the innovation context and for network learning. They can be seen as currently important and topical views on learning that have gained increasing attention in research and practice. Also, the aim has been to present versatile views to highlight their differences and to provide implications from a wide variety of perspectives. These views are the conversion of explicit and tacit knowledge, learning for exploitation and exploration, absorptive capacity, organizational memory, systems thinking, and dynamic capabilities, which will be briefly introduced in the following.

The inclusion of several different theoretical approaches to learning in this study helps to build a more versatile and dynamic picture of the learning phenomenon. This is needed because of the versatility and complexity of the innovation context especially due to the information intensity and process complexity in the network, which means that using multiple approaches to network learning depending on the situation is more effective and flexible than only relying on one perspective. It also gives a wider understanding of the possibilities and challenges of learning, although concentrating on one specific theoretical explanation might provide deeper insights. There are several viewpoints in the literature that have been left out of the study, such as for example communities of practice (CoP) and specific workplace learning practices, which are sometimes referred to also in the inter-organizational context and in connection with innovation, but mainly concentrate on the organizational level of learning.

All the above-mentioned views on learning have their own interpretation of what is seen as important in learning, and this also results into different implications in terms of what is seen as effective learning and how to support it when considering the theories from the point of view of inter-organizational or network learning. This enables a many-sided picture of the learning phenomenon, when the contribution comes from combining different views and the resulting understanding of the learning phenomenon is built on the special characteristics of several perspectives covering a wide variety of viewpoints instead of concentrating only to one specific viewpoint and limiting the range of implications. To support learning in innovation networks effectively, many viewpoints are needed also because of the complexity of the situations and challenges of learning in this context. In conversion of explicit and tacit knowledge (Nonaka & Takeuchi, 1995; Holmqvist, 1999) the role of tacit and explicit knowledge and the knowledge creation processes are at the focus, and these processes also exist between organizations. In exploitative and explorative learning (March, 1991; Nooteboom, 2004), organizational routines for exploitation and for exploration should be balanced, and the needed balance varies in time according to the stages of the network relationship. In absorptive capacity or relative absorptive capacity view (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Dyer & Singh, 1998) the similarity of the new knowledge to the previous, existing knowledge plays a key role in learning, and the level of knowledge (basic/specialized) also affects this.

Literature on organizational memory (Walsh & Ungson, 1991; Moorman & Miner, 1997; Koistinen, 2003) sees organizations as creators, users and storages of knowledge, and learning by doing and experiencing is highlighted. Learning is stored in multiple physical and non-physical forms. The creation of inter-organizational routines and processes, and creation of formal and informal networks between partners is encouraged. In systems thinking (Senge, 1990; Sterman, 2000; Argyris, 1999) the role of feedback, holistic view of the network and the interdependencies and interactions of partners are emphasized, thus highlighting the importance of building inter-organizational processes and practices to support mutual understanding and generation of feedback. The dynamic capabilities view (Teece et al., 1997; Dyer & Singh, 1998) is based on the idea of complementary assets and continuous ability to renew and adapt competencies and routines through learning also between partners.

3.2 Challenges for learning in innovation networks

Learning in co-operation and networks has special challenging features, when the cooperation focuses in the area of innovation. Challenges for learning have been studied in this research on a conceptual level in publications I, II and IV particularly from a systemic point of view, recognizing that networked innovation activity is complex and has some inherent problems related to learning. Another, more concrete approach to learning challenges has been taken in publications V and VI which study them from the point of view of distributed virtual development teams, often organized as projects.

3.2.1 Learning challenges in innovation networks

An important special feature of innovation activities when compared to other activities in organizations is the inherent complexity of innovation processes, due to several reasons such as task complexity (the complexity of individual tasks)**,** which places special attention on learning and knowledge management capabilities (Söderquist, 2006). In addition to this, there is combinatory complexity (complexity as a result of the number of interactions, or combining individual tasks) which is the result of a large number of agents interacting with each other and the number of process steps, and also dynamic complexity (complexity as a result of changes) because the processes and the interactions change over time and include contingencies and tight interdependencies between agents and process steps which lead to increased complexity in coordination (Hallikas et al., 2008). For learning, all these different types of complexities mean more challenges in knowledge creation and in getting feedback.

Another specialty of innovation-related learning challenges is the knowledge intensity of the innovation process (Eppler et al., 1999). The tightening development time requirements of the markets mean that the information becomes outdated fast. Also the heterogeneity of knowledge poses a challenge because there needs to be sufficient fit between the knowledge bases of co-operating partners (Weck, 2006). This is one of the main conditions to overcome, but there are several individual, organizational and technology-related barriers for knowledge sharing (Riege, 2005).

One of the important learning barriers in knowledge sharing between partners is the need to avoid leaking knowledge, since the risk of technological leakage, the unwanted transfer of knowledge, is real in collaborative innovation. (Nooteboom, 1999; Oxley & Sampson, 2004). The type of knowledge processed in innovation activities is to a large extent tacit, and often classified or highly sensitive, so it requires willingness to share knowledge and sufficient trust. Trust is a necessary basic requirement for collaboration, and it has been shown to exist also on inter-organizational level, not only inter-personal level (Seppänen, 2008).

According to several learning theories, learning requires feedback (Argyris & Schön, 1996; Crossan et al., 1999). Problems related to feedback are emphasized in a network between several partners, where most of the feedback comes from external sources, and the time lag and chance for misunderstandings grow when there are several partners involved. Typically in innovation, the development cycles are long and in distributed development or in a network also the physical distance is significant, which prevents timely and accurate feedback. The feedback can also be missing or misperceived (see e.g. Eppler et al., 1999; Holmberg, 2000; Rigby et al., 2000).

3.2.2 Learning challenges in virtual innovation teams

In addition to the learning challenges in innovation networks in general, if the co-operation is organized by virtual teams there are some further challenges related to learning due to the virtuality of the co-operation. These have been discussed for example by Rosen et al. (2007), Stevens et al. (2006) and Arola et al. (2007). In virtual teams, the communication flows may be lower than in collocated teams due to distance, cultural differences and language, and distance also reduces social similarities and shared values (Latane et al., 1995). Thus, the capacity to understand each other may be lower and there is an increased possibility for misunderstandings due to limited communication possibilities and lack of non-verbal communication (Hiltz, 1986). An intensive communication flow with also informal conversations is usually required for forming a "collective mind", a shared understanding and mental models (Weick and Roberts, 1993). Intensive interaction has a crucial role also in the development of a team identity, which gives a sense of belonging and purpose to the team members and is one important factor for the success of virtual teams. Also challenges and limitations related to the features and use of technical tools by the virtual teams might limit the communication and thus affect learning within teams and also learning from the team to the organizational level.

Knowledge sharing is a necessary prerequisite for any learning to take place, and sufficient level of trust is required for the willingness to share knowledge. Thus the lack of trust might prevent knowledge sharing and learning. The challenge of trust discussed earlier in the context of innovation is even more evident in virtual teams, since trust has been identified in several studies as one of the cornerstones for virtual teams (e.g. Gibson and Manuel, 2003; Järvenpää et al., 1998; Järvenpää and Leidner, 1999). The distance and possibly limited communication might lead to slower trust development, and also conflicts might occur reducing trust.

According to Nonaka and Takeuchi (1995), the generation of knowledge happens through converting and combining individual, tacit knowledge (Polanyi, 1966) to shared, explicit knowledge. In a virtual environment, the tacitness of knowledge and the embeddedness of

knowledge into ways of living or cultural artifacts (Czarniawska, 2001) present another challenge for learning and knowledge generation. The utilization and transfer of tacit knowledge through for example informal meetings might be challenged by distance and limitations of the software-based tools (Khalifa and Kwok, 1999). The tools used as well as the norms and roles of using different tools might also be limiting the creativity of the team (Shachaf, 2008).

The virtual teams might also be experiencing challenges in exploiting the earlier experiences of the team members and in forming shared organizational memory, for example trusting others' experiences and thus remaining unable to use them for the team, or in recognizing who knows what (so-called transactive memory) (e.g. Akgün et al., 2005; Austin, 2003). Also in virtual teams, the maintenance of transactive memory might be limited (Alavi and Tiwana, 2002). Some learning challenges are related to virtual team management and leadership, such as maintaining the information flow, synergy and common goals, and the challenge of finding solutions to complex conflicts (Shin, 2005). Since innovation and product development activities are typically organized as projects, also the special challenges of project learning need to be considered (Schindler and Eppler, 2003), because they might hinder the wider organizational learning from the virtual teams.

3.3 Network learning and innovation

Because of the importance of managing knowledge and creating new knowledge as the essence of innovation process (Tidd et al., 2001), learning is a crucial process within innovation networks. In an innovation context, learning aims generally at the improvement of the processes, flexibility of operations and speed of innovation. The complexity of the innovation and the network context requires effective learning that enables renewal, speed and flexibility. Because of these requirements, learning is also very challenging in the context of innovation. Innovation networks have been increasingly researched in innovation management and network literature (Tidd et al., 2001; Borgatti & Foster, 2003), but the aspect of learning has been brought forward in innovation networks by only a few writers, such as Calia et al. (2007) and Rycroft & Kash (2004). Learning in the context of innovation has been discussed for example by Vera & Crossan (2005) through improvisation as a means for innovation-related learning, but the focus is more on the organizational or team level, just as for example Chapman & Hyland (2004) discuss the complexity and learning of organizations in product innovation.

The existing studies on learning in innovation context focus mainly on organizational or inter-organizational levels of learning within one or between two organizations in innovation co-operation (see e.g. Faems, 2007), such as joint ventures or strategic alliances (Inkpen & Crossan, 1995). The network level learning with multiple participating organizations is a novel topic for research as the phenomenon becomes increasingly important in practical innovation management.

The possible solutions to learning related challenges, or the ways to support learning in innovation networks particularly on an inter-organizational and network level have been divided in the study into processes and practices, the organization and technical systems, which all need to be considered together and modified if necessary. These three complementing aspects of organizational development are commonly referred to in strategic

management literature and practice when introducing profound changes such as new business models. The same classification has been utilized in the publications of the thesis with variable emphasis, some concentrating more on the practices and processes, some on the organization and IT systems.

3.3.1 Processes and practices

Based on the literature, some general suggestions can be found for the practices and processes for learning in and by innovation networks. In addition, from the point of view of the six learning approaches discussed earlier in section 3.1.3, some implications for learning in inter-organizational innovation networks as well as practices based on these can be identified. Nooteboom (2006) stresses the importance of outside relationships and networks to allow sufficient cognitive distance that enables innovation, and also to learning and developing new competencies. An optimal cognitive distance is achieved when the partners can offer others something new, but can still understand and come to agreement with each other. The optimal structure of the network and the strength of ties between network participants are dependent on the type of innovation pursued, so all these have to be compatible with each other. Håkansson et al. (1999), have concluded that in general, networking and participating in external processes increases learning. Faems et al. (2007) have studied knowledge transfer in inter-firm R&D relationships and the factors affecting the initiation of knowledge transfer are the willingness to disclose knowledge and the ability to acquire and assimilate knowledge. To continue the knowledge transfer, the market threats have to stay limited and the complementarities of the co-operation extensive, or otherwise the knowledge transfer will dissolve. Miettinen et al. (2008) have studied the evolution of an organization through its development projects and see the product development as an intertwined unit of product, network and capability development, which is also path-dependent according to the earlier development activities.

Sobrero and Roberts (2001) have reported a trade-off between short-term efficiency and long-term learning effects in inter-organizational product development, and call for aligning the goals of the co-operation. Prerequisites and obstacles for mutual co-operation and learning have been discussed in supplier-customer product and process development by Stjernström & Bengtsson (2004), who see the role of a coordinator who facilitates learning and a mutual willingness to learn as necessary preconditions. The practical means to overcome barriers of knowledge sharing include job rotation and other practices to stimulate both tacit and explicit learning. In their empirical study of organizational learning processes in innovation, de Weerd-Nederhof et al. (2002), found evidence of different tools or practices used for learning, such as job rotation, innovation process planning (activities, responsibilities, networks, assumptions), and project reviews. Heikkilä et al. (2004) have described learning in networks as "a multi-organizational iterative process consisting of simultaneous learning cycles", since learning happens on all levels from the individual to the network level. They have also listed some learning methods for networks, which include workshops and brainstorming sessions, homework of individual partners, scenarios, role play, benchmarking and confidential discussions.

The implications of the six selected learning views for learning in inter-organizational innovation networks, as well as learning practices, are discussed in more detail in publications II-IV. To support the conversion of tacit and explicit knowledge as Nonaka &

Takeuchi (1995) and Holmqvist (1999) have suggested, there is a need for making the knowledge creation processes explicit and to support both formal and informal innovation processes. This means the identification and mobilization of tacit knowledge and organizing formal meetings, documents and instructions, and having explicit objectives for learning as well as a possibility to share knowledge in an informal setting.

Exploitative and explorative learning (March, 1991; Nooteboom, 2004) emphasizes the importance of routines for exploration as a source of innovation and renewal. The future planning on the network level and renewal of the network relationships are based on for example identifying the needed balance between explorative and exploitative routines in different stages of the relationship, and learning requires commitment, so keeping the relationships alive on all levels is encouraged.

Absorptive capacity and relative absorptive capacity (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Dyer & Singh, 1998) discusses the similarity and specialties of innovation partners, in terms of knowledge bases, organizational structures and policies, knowledge-processing style and commercial objectives to ensure effective inter-organizational learning. The identification of basic and specialized knowledge by taking stock of the existing knowledge base gives a possibility to evaluate similarity, and discussing the objectives and future plans with the innovation partners helps in finding possible common goals for the network. To enhance organizational memory (Walsh & Ungson, 1991; Moorman & Miner, 1997; Koistinen, 2003) the network organizations should create common innovation processes and routines and other memory forms together. Modeling and describing current processes and routines of organizations and formal databases, as well as developing common transactive memory is important.

Systems thinking (Senge, 1990; Sterman, 2000; Argyris, 1999) -related practices or processes can include describing the network and its objectives to achieve shared understanding of the whole network and the network partners' roles and interdependencies. Ensuring feedback processes in the innovation process as well as designing the product, service and process architecture together with network partners and the identification of virtuous and vicious loops in the development projects are other means to enhance learning from a systemic perspective. Dynamic capabilities approach (Teece et al., 1997; Dyer & Singh, 1998) aims to integrate complementary capabilities, and in innovation networks this might lead to better chances for radical innovations. The integration is done through identifying own capabilities and critical resources for innovation especially from the network point of view, through continuous re-evaluation and developing routines together with partners.

3.3.2 Organizational structures

The organizational structure through which the innovation co-operation is carried out can also be regarded as one solution to enhance learning. The organizational solutions to support innovation can be carried out in different levels and in different forms. Organizing innovation activities as networks, inter-organizational projects or virtual teams provides the needed flexibility and versatile competencies for managing innovation.

The network structure and participating in networks generally increases learning (Håkansson et al., 1999) and is in itself a supporting organizational form for learning. The networks which are formed explicitly for the purpose of learning are called learning networks (Knight, 2002) and are defined according to Bessant & Francis, (1999) as "a network formally set up for the primary purpose of increasing knowledge, expressed as increased capacity to do something". As the primary objective of these networks is learning, they can be utilized in also other areas of business operations than innovation. The concepts of learning and networks have also been combined for example by Heikkilä et al. (2004) who have developed a framework of a learning business network, building on the literature of learning organizations and knowledge creation. They also note the dynamic and often cyclical nature of development in a network, and propose several examples of practical methods for learning.

One of the widely used organizational forms in innovation is virtual teams, and they can be seen as facilitators of learning in many ways. Although there are several challenges for learning due to virtuality, virtual teams also offer some benefits in knowledge creation that are especially valuable for innovation networks. These challenges and benefits have been discussed in more detail in Publications V and VI. The ability to cross geographical and organizational borders with the help of technical tools allows for example the use of best available resources (Martins et al., 2004), as well as combining existing knowledge fast to generate new knowledge and innovations.

The heterogeneous backgrounds of the team members and the different knowledge and specialization areas can also be utilized in innovation networks to enhance creativity and produce versatile solutions (Ling, 1990, in McDonough III et al., 2001). The cognitive differences or distance and versatile mental models can help in achieving double loop learning by being able to question self-evident issues and traditional behavior in the team (Nooteboom, 2006). This can lead to better exploitation of opportunities and creating new solutions.

The use of virtual teams and ICT tools enable regular and frequent, fast communication when needed (Robey et al., 2000), including review meetings that support learning. Other ICT-related benefits are for example the flexibility in organizing team training and the possibility for anonymity, which can help in expressing also negative experiences and reduce stereotypes (Shachaf, 2008).

3.3.3 Technical systems

Technical systems and tools such as software applications and databases are an integral part of any organization today. As one cornerstone to the solutions, they can also facilitate learning if defined and used properly. In practice, ICT support for network learning has proved to be challenging, for example Heikkilä et al. (2004) have found that sharing information between partners through groupware requires a more fine-level classification of information confidentiality than available in current systems and better compatibility of the systems. Also, they note that the situations when someone leaves or enters the network pose problems in terms of information ownership and confidentiality.

The technical support for organizational learning has been researched on an organizational level quite extensively, and as an example, Robey et al. (2000) show in their review that especially the development of distributed organizational memory should be focused on when developing organizational systems. This includes the conceptual design of the memory systems, knowledge representation, retrieval, and use. Other forms of collaborative technologies focus more on supporting communication and facilitating shared understanding, which enable learning. These kind of technical tools, especially the new web 2.0 applications are also used by virtual teams to enable real-time collaboration, shared understanding, communication and knowledge sharing, resulting to better learning.

In a co-operation network, simulations, gaming and for example process mapping can be used as technical methods for creating shared understanding through communication (Wenzler, 1999). Simulations and modeling have not been included as a separate topic in this study, although they would support especially the ideas of systems thinking view of learning in e.g. generating a shared and holistic picture of the network activities and partner roles.

4 Research Strategy and Methodology

This section explains the strategy and methodological choices of the research, giving a detailed view of the research approach, qualitative research, and the methods used for data collection and analysis, case research with theme based interviews and qualitative content analysis. Also, it evaluates the suitability of the chosen research methods based on literature.

4.1 Research approach

The choices every researcher needs to make concerning the basic principles are the level of objectivity or subjectivity, the data, role of the researcher and research design. Different approaches rely on different views of the world, of the nature of knowledge, nature of human beings and also the methodological possibilities in producing knowledge. The two philosophical paradigms that represent the different ends of the continuum are the subjective, phenomenological or social constructionist approach and the objective, positivist approach (Easterby-Smith et al., 2008). Traditionally, the objective or positivist approach has been widely used by natural scientists and the subjective, phenomenological approach has been favored by social scientists. The basic assumptions and principles of both are gathered and illustrated in Table 3.

Table 3. Positivist and social constructionist research paradigms (modified from Easterby-Smith et al. 2008, p. 59; ibid.,1991, p. 27; Burrell & Morgan, 1979).

	Positivist / objective	Social constructionist / subjective/ phenomenological
Background beliefs	• The world is outside and objective	• The world is socially constructed and subjective
The role of the researcher	• Independent • Focus on facts • Causal relationships and natural principles • Simplifying the phenomenon • Hypothesis and testing them	• Part of what is observed • Focus on meanings • Understanding the phenomenon • Holistic view of the situation • Developing interpretations based on data
Preferred methods	• Operationalizing concepts • Statistical probability • Wide samples, random selection	• Methods for bringing out different views • Theoretical abstraction • Small number of research objects studied in detail or during a period of time, selection for specific reasons

In this research, the subjective or social constructionist approach is used as a background philosophy, and it relies on the interpretative research tradition in finding meanings for and creating understanding about the concepts of organizational learning in the innovation network context. Although in practice the differences between the paradigms are not as clear as on the philosophical level, the researcher has adopted a social constructionist approach, which means that in research outcome terms, the aim is bringing forth several interpretations of reality and a rich empirical picture of the studied phenomenon. This is based on including

multiple differing perspectives to allow a versatile, holistic picture which complements and deepens the current understanding of the phenomenon.

The issues related to the research questions are studied both from the point of view of literature on innovation, networks and learning as well as in practice through interviews in several organizations and networks. Because the objective of the research is to deeply understand a complex phenomenon that is hard to define and measure, and to explain this phenomenon in more detail through theoretical concepts, not to actually test a theory, the qualitative research approach has been mentioned as capable of supporting this type of research very well (Easterby-Smith et al., 2008; Denzin & Lincoln, 2000). The choices of research methodology in this study are illustrated in Figure 6 below.

Research approach	Qualitative research
Research method	Case study
Data collection approach	Interview
Data collection method	Theme interview
Analysis approach	Interpretative
Analysis method	Content analysis
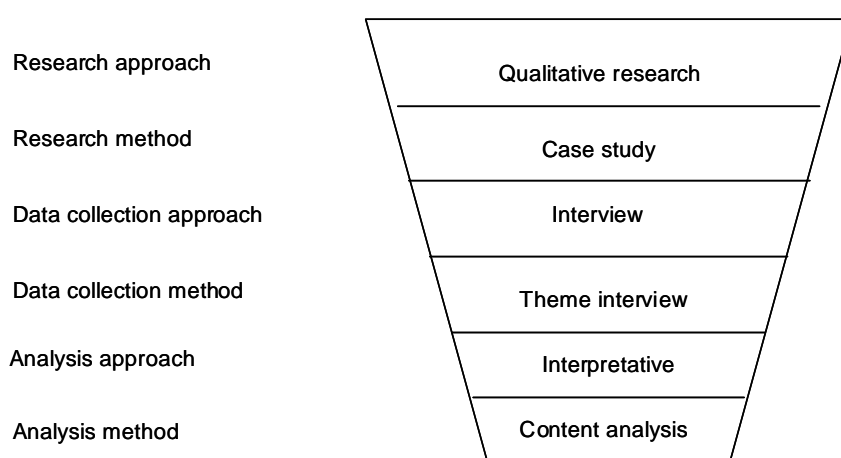
Figure 6. Summary of the research approach and methods

Qualitative research is a research approach that can be used in various fields for many kinds of research problems. The terminology is wide, partly overlapping and unestablished, although it has been used in different forms for many decades. The contents and specific methods used have varied over time (Denzin & Lincoln, 2000). Some writers argue that the term qualitative research is incorrect, since there is only qualitative (non-numerical) data that can be collected and analyzed with different methods (Tesch,1992). The language and words in the research data are the central research material, and the research is based on the analysis of communication situations. There are numerous research types in social sciences that can be included in this type of research. Thus it is important also in this thesis to identify and describe the research approach and methods in a detailed level, so that the reader can follow how the research was carried out and how the results were obtained.

Some special features of qualitative research are according to Eskola & Suoranta (1998): first, the data collection method, which concentrates on collecting data in a text form, second, the research plan which evolves through the whole process, third, the participation of the research subjects, fourth, the selection of a few interesting cases and a deep analysis of these, fifth, the data analysis that tries to understand the essence of the phenomenon, sixth,

research without hypothesis or pre-assumptions, seventh, the freedom of the researcher and subjectivity, and eighth, relying on narrative material.

Denzin and Lincoln (2000, p. 8-10) list several issues, where qualitative research differs from quantitative research. These are for example the relationship to positivism, postpositivism and postmodernism in what kind of reasoning is accepted in scientific research and what is defined as science, the focus on the micro level of activities (individuals, specific organizations), researching every-day life and actions, and producing rich descriptions of the phenomenon and situation which is studied. Qualitative research approach seems appropriate, when the aim is to interpret experiences and to understand some specific practical situation. This does not mean, however, that qualitative and quantitative research approach could not be used together to examine the same issue, and to complement each other.

Qualitative research has several challenging elements. Some commonly mentioned are lack of clear objectives in the beginning, unsuitable data collection level for the research problem, unsuitable data collection method, mistakes in analysis or unsuitable analysis method (Eriksson, 1986). In addition, Shank (2006) presents a list of mistakes called "the deadly sins" of qualitative research: competing with quantitative research, advancing the personal aims of the researcher, too much rigidity in research planning, accepting easy solutions, sentimentality, narcissism and accepting a safe, well-done but mediocre research. Silverman (2005) recommends that the use of qualitative research approach has to be based on what needs to be found out, how detailed level of analysis is needed, how have other researchers studied a similar issue, what practical limitations have to be taken into account, which methods allow most learning about the subject and which methods the researcher personally prefers.

The topic of this thesis, inter-organizational learning in innovation networks, combines many areas of literature and theoretical views. This is a relatively new research area, in which the literature is still accumulating, so the basic task of the researcher in this situation is to create new knowledge through combining existing areas of knowledge. This enables to have a better, more holistic picture of the complex phenomenon in question. The research approach in this thesis is not so much relying on traditional analysis approach, which tries to understand a phenomenon by dividing it into smaller parts and further analyzing these, but rather the aim is building a synthesis where combining different factors and viewpoints related to the phenomenon results in a more accurate and versatile picture of the phenomenon as a whole than before.

4.2 Literature review

The research process for the thesis started with literature reviews and building theoretical understanding of the different aspects related to the research topic of inter-organizational learning in innovation networks. The results of this research phase are reported in Publications I-III. As the knowledge of the subject elaborated and the researcher's understanding increased, also the original focus of the research was widened to include the practical perspective of virtual teams which are used to organize innovation co-operation. Also this area was first studied based on the literature from the perspective of learning, and reported in Publication V.

The literature reviews were conducted together with multiple researchers, using scientific journal articles from full text databases concentrating mainly on business and management journals, as well as established and recent books as the source for material. Review articles and recent publications were especially emphasized. The database search keywords were most often some combinations of the terms network, learning, and innovation, or their near synonyms or detailed forms (for example inter-organizational learning, network collaboration, product development etc.). The source material was considered relevant for the first part of the study if it provided input for innovation networks, learning in innovation, inter-organizational or network learning, and for the second part of the study, search keywords related to virtual collaboration, distributed product development etc. were used in the same manner. The heuristic evaluation was based on the content of the article, not necessarily title or keywords. When there were multiple relevant articles identified from the same author, also the author's publications were checked for example from their own web pages in addition to databases.

By organizing the material, some viewpoints on learning came up repeatedly, and the search was refined to include more material on those specific views. The final selection of the six viewpoints on learning which are utilized in the research was based on many factors: they were considered relevant to the research topic, currently important views on learning that have gained increasing attention in both theoretical and empirical research, and also practice. The versatility of the views highlights the differences and provides implications from a wide variety of perspectives. The same kind of search and analysis process was used with the material on virtual teams and their challenges and benefits for learning; when the same issues came up in several sources, the search was focused according to that.

4.3 Case study method

Case study method has been chosen for the empirical part of this research because the aim is to understand a relatively new phenomenon more deeply and in detail than before, and cases are recommended for example when the research area is new and there is limited amount of knowledge available about a complex phenomenon (Yin, 1994). Case studies also support the idea of qualitative research producing rich descriptions of every-day life, which in this research could be interpreted as the daily activities of the innovation network. Case study is about choosing the target of research, what is being studied and what needs to be found out, more than choosing a method. A case can be almost anything that is a special, unique, and a limited system that acts according to some pattern (Stake, 1995).

Case study research can be divided into several research types according to the background assumptions made, what are the research aims and whether comparisons between cases are made or single special case is presented. Eriksson and Koistinen (2005) present the following typology of cases: self-valuable, instrumental and collective case, descriptive case, explanatory case, explorative case and intensive and extensive case. In a similar manner, the reasons for studying a case may vary, and the knowledge interest might be one of the following: the case and/or a description of it is valuable in itself, or it can be used as a tool for understanding a larger issue, or in collective cases to compare different cases to allow generalization (Stake, in Denzin & Lincoln, 2000).

In this research, the case studies are used primarily in a descriptive and instrumental way, in order to better understand the phenomenon of learning and to some extent also explaining the linkages found between theory and practice. Although the final case descriptions in the Publication IV are very concise, they aim at giving a many-sided picture of the real-world environment of collaboration in the studied innovation networks and of the challenges and practices related to learning especially on the network level.

4.4 Empirical data collection

The empirical data collection on both research areas took place after the literature studies, and interviews were chosen as a primary data collection method. The results of the empirical studies are reported in Publications IV and VI which also give a more detailed description of the research methods.

Many kinds of data collection methods can be used in case study research to find out the specific issues of interest in each case. For example interviews and narrative stories are possible options for data collection (Stake, in Denzin & Lincoln, 2000). The choice of data collection method should reflect the research strategy and approach, and also the theoretical views used have an impact on the choice. In qualitative research, the methods do not need to be very strictly planned in advance, but outlining the research structure and choosing the methods early on makes the work easier.

Silverman (2005) has written about several data collection methods and links interviews in qualitative research with a case where the questions are open-ended and the number of research informants is relatively small. Two basic choices need to be made when deciding about the data collection method: what level of generalization is desired, and what level of analysis (how deep understanding of the phenomenon) is the goal (Eriksson, 1986). When choosing the data collection and interview method it has to be taken into consideration what kind of role the interview material has in the research, what analysis method will be used as well as how the data answers the research questions (Silverman, 2005).

4.4.1 Interview as a data collection method

Interviews are part of every-day interaction in modern society, they do not limit to only academic research purposes in data collection. Gubrium and Holstein (2001) even talk about the concept of interview society, because everything is built around transfer of information through interviews.

Interaction between the interviewer and interviewee is a central element affecting the results of the interview, and although an interview resembles every-day discussions, it has special features such as actions needed to begin and to end the interview, as well as the institutional role which can be seen in that the interview is often taped or the interviewer takes notes of the discussion. (Ruusuvuori & Tiittula, 2005) Also a shared understanding and a way to interpret reality is important for a successful interview. Thus the interviewer needs to realize her own significance and role in how the text is constructed and in the interview situation as a whole (Tienari et al., in Ruusuvuori & Tiittula, 2005).

A limitation of interviews as data collection method is that words are always somewhat dependent on interpretation, even if the wording of questions would be carefully thought of. With an interview, it is possible to gather a lot of information effectively and a versatile picture of a situation, where people and their actions are the central focus of the research. Interviews can be carried out as personal or group interviews, it can be aided by some technical devices and it is a single event or a series of events. (Fontana & Frey, in Denzin & Lincoln, 2000)

Different types of interviews have been widely discussed in the literature. A traditional distinction of interview types is between a structured survey interview, a semi-structured e.g. theme interview and a fully open, deep interview. In addition, different forms and mixtures or variations of these such as life-story interviews, group interviews and computer-aided interviews are possible (Gubrium & Holstein, 2001). Other interview forms include for example story-telling or narrative approach which is suitable especially for life-stories and other personal interviews, interviews conducted with groups such as focus group interviews, and computer-aided interviews (Ruusuvuori & Tiittula, 2005; Gubrium & Holstein, 2001).

4.4.2 Theme interview

A widely used form of interviews is a semi-structured or guided interview, which is based more on the discussion between the interviewer and the interviewee than on ready-made questions. Semi-structured interview is a suitable and many-sided data collection method for collecting qualitative material, and it has been used also in this research. Theme interview is one way of organizing such an interview, and it is based on a list of themes, where the formulation of the questions varies according to the situation and the order of questions can change. Also the interviewer and the interviewee can formulate the questions together during the interview, and one theme can contain several questions (Eriksson, 1986).

In addition to the list of themes or question areas to guide the interviews, a qualitative questionnaire was used during the interviews to complement the data in the part of research concerning virtual teams in Publication VI. The questionnaire form was used to enable the respondents to evaluate the importance of the factors related to the research subject, contributing and inhibiting factors for learning, and to connect these to the life-cycle stages of the virtual team. The evaluation of importance was done on a scale from 1 to 5, where 1 was not important and 5 very important.

4.4.3 Selection of cases and interviewees

As noted previously in the discussion on case-study method, the selection of cases has great importance and there are several factors related to the overall research design that need to be considered in the selection process. In this research, the selection of cases and informants was based on "purposive sampling" (Easterby-Smith, 2008) or to "information-oriented selection" (Flyvbjerg, 2006), partly based on the existing contacts of the researcher. In the information-oriented selection, the purpose is to maximize the usefulness of information based on small number of informants and even single cases. The expectations about the information content of the cases (Flyvbjerg, 2006) and on the expertise of the informants guide the selection. This was seen as an appropriate strategy for case selection, because the

research topic is new and complex, and requires the respondents to have own experience of the context and the topic. Also, wide coverage or representation was not an objective in this study, since the research approach is more qualitative and the aim is to increase understanding on a specific area. Although the number of selected cases and interviewees was small, saturation of the data was achieved in the sense that the responses of interviewees brought up similar issues. At the same time, the content validity of the responses was ensured by interviewing several persons from the same case network.

In the first part of the empirical research concerned with different learning views and practices, the aim was to have a small number of collaboration networks in innovation or product development area to participate the study, so that there are multiple respondents from the same network. Each analyzed case consisted of one collaboration network. The initial contact person in the organizations was a previously known person, who in some cases was also one of the interviewees, but more often recommended other interviewees, Contacting the interviewees was done by the researcher.

In the second part of the empirical research concerned with virtual teams, the setting was different as the primary interest was on distributed teams within the same organization, and the interviews were carried out in two organizations representing different industries which were located in different countries (Finland and France). This setting was chosen because of the assumed cultural differences, which were anticipated to have an effect on the use of virtual teams and on the behavior of the teams, thus resulting in differences regarding also in learning and in the perceived virtual team challenges or benefits for learning. This helps also the transferability of the results, when the original research setting includes great differences, it means that the results should be transferable to a wide variety of contexts. Again, the original contact person in the organizations was known, but in this case the target group of the interviews was more limited due to the need to have respondents who have experience in working in virtual teams or managing them. In the Finnish interviews the invitations to participate the interviews were sent by the organization's manager, and the interested persons contacted the researcher, whereas in France the interviews were organized with the management of the organization. Also, in both interview series the expertise of the previous respondents was utilized to find more respondents from their own organization or from their partners by asking them in the end of the interviews, if they could name additional persons to interview, which is a form of "snowball sampling" (Easterby-Smith et al., 2008). The invitation and introduction letters to the interviews, as well as the lists of themes are attached as Appendices I and II.

4.5 Case data and content analysis method

In the first empirical study on learning views and practices, the empirical research was started with semi-structured theme interviews of three collaboration networks, in which two to three participant organizations per network were interviewed, and normally there were one to two interviewees per organization, so altogether nine interviews were performed. The organizations included in the study represented also different roles in the value network, suppliers and customers. The results of this empirical study are gathered in publication IV.

In the second empirical study, reported in publication VI, the focus was on virtual teams' learning. The participants represented the internal networks of two different organizations

located in Finland and France. Altogether nine interviews were performed, six in Finland and three in France. In the virtual teams research, the respondents were team leaders who had long experience with virtual tools and had on-going virtual projects or long-term teams. In all the interviews, the primary interview data was collected from persons who participated in the product, service, or process development in the organizations and had practical experience on the studied phenomenon, and generally represented management level. A summary of the empirical data collection is presented in Table 4 below.

Table 4. Summary of the empirical data collection in Publications IV and VI

	Publication IV	Publication VI
Title	*"Challenges and practices for learning within and by innovation networks"*	*"Effect of virtual teams for learning in innovation: contributing and inhibiting factors"*
Data gathering	Literature, theme-based interviews	Literature, theme-based interviews, qualitative questionnaire
Participants	• 8 organizations in 3 collaboration networks • Managers responsible for product / service development or development collaboration • Scientific partner in 1 network	• Internal networks of 2 organizations • 6 interviews in Finland, 3 in France • Managers and experienced participants in virtual (development) teams
Total interviews	9	9

According to the principles of case research, the researcher later needs to make interpretations based on the collected research data about the situation and the subject of the research, not only record the information as such. Looking for meanings in the transcribed material (interview or other data) is a central phase in qualitative research (Warren, in Gubrium & Holstein, 2001, pp. 83-85). One analysis method to find meanings in texts is content analysis, which has been widely utilized for many decades for example in social sciences and especially nursing research (Cavanagh, 1997; Elo & Kyngäs, 2007), but only recently applied to management research. Examples of managerial research utilizing content analysis can be found related to intellectual capital, leadership and accounting areas (Insch et al., 1997; Beattie & Thomson, 2007). In this research, qualitative content analysis has been utilized in the interview analysis of Publication IV.

The process of qualitative content analysis is described by Cavanagh (1997) as a suitable method to finding meanings and intentions through systematic classification of data. It can be used with quantitative or qualitative data and the analysis can be either inductive (categorization based on the data) or deductive (categorization based on earlier knowledge) (Elo & Kyngäs, 2007). In this research, the categories were initially formed based on the literature but also new categories were formed based on the data if necessary during the analysis process, so the approach can be called theory-guided. The analysis task was divided between four researchers so, that after everyone had analyzed the first interview to establish common ground, they concentrated on analyzing a defined network.

In the second set of interviews the analysis of the open interview questions was based on heuristic analysis of the interview data by two researchers and establishing a shared understanding of the data between them, and in addition to this, the analysis of the

questionnaire items was done through tabulation and analyzing the numerical data by counting averages and other key figures to describe and highlight the findings.

Triangulation has also been utilized throughout the research process by combining different theoretical views, sources and tools of data collection as well as by multiple researchers as co-authors. The theoretical triangulation is based on the different literature streams mentioned earlier: network, innovation and learning literature and theories. The aim is to explore and understand the combined area of these views. Empirical data collection has been done with interviews, so the primary data is the interview records and as supporting secondary data also the publicly available documents of the organizations have been used to support the analysis. At the first stage of the empirical research, suitable organizations for the interviews were evaluated based on the content of their web pages and annual reports: do they emphasize the learning, network and innovation aspects of their operations in their public material. In the later stages of analyzing the interview data and writing the cases, the secondary material was used to complement the descriptions of the organizations, their industries and partners.

Based on the above reasoning, and because of lack of quantitatively measurable factors in this type of study, and because the aim is to understand the phenomenon, not to test hypothesis or create new theory, qualitative research approach has been chosen for this thesis. The phenomenon of learning especially on the network level is not very well known, so quantifiable factors are hard to find. Qualitative research approach, case study method and theme interviews as data collection method seem to fit the aims and topic of the thesis research, since support was found in the literature that all these are suitable for research where the topic is many-sided and combines existing concepts, and there is not very much prior research.

5 Summary of the Publications and Review of the Results

This section gives an overview of the publications, describing the objectives, the most important research results and the contribution from the point of view of the thesis research questions, and each publication's role in the thesis and the links between them. A summary of the publications is presented in Table 5 on page 55.

5.1 Publication I

The first publication of the thesis, *"Systems thinking and learning in innovation process"* acts in this thesis as a general introduction to the complex nature of innovation and the challenges for learning that this complexity presents, especially from a systems thinking point of view. In this paper, the aim is to connect systems thinking and learning in the innovation context, and to study what kind of learning challenges exist in innovation from the point of view of systems thinking and how the systems thinking approach can be applied to support learning. The paper emphasizes the importance of learning and systemic thinking in innovation, to enable efficient learning in complex environment. Especially, if the aim is to create radical innovations, then generative, double loop learning is needed to challenge the existing mental frameworks and practices.

The challenges for learning have been discussed in the paper from the point of view of systems thinking, especially focusing on the systems thinking -related concept of dynamic complexity, its elements and its implications (see e.g. Sterman, 2000), as well as the feedback processes in innovation-related learning. The level of the learner as described in this publication is mainly the decision-maker, individual or group, but it also reflects on organizational level. This conceptual review brings together areas of literature that have been combined in only few articles, by first describing the challenges for learning and then considering the possibilities and significance of systems thinking for learning in innovation, based on previous literature.

Systems thinking and the methods based on it present many possibilities to support efficient learning in complex environments, such as innovation activities. These methods include soft systems methodology (SSM), systems-based network analysis, and system dynamics modeling mentioned in the article as possible solutions. Since systems thinking is such a wide approach, covering many schools of thought and practice and the origins coming from different disciplines, this article does not give specific instructions on how to apply these methods. The variety of possible approaches allows utilizing different systems methods for learning in diverse ways on the individual, team and organizational level. Further examples of the approaches based on systems thinking include for example learning systems theory or cognitive maps.

The results of the study are significant for the improvement of the efficiency, speed and flexibility of innovation activities that can be achieved through systems thinking and learning. The role of the paper in the thesis is to present a background for the subsequent articles in the thesis by describing innovation process and innovation networks as a complex environment where learning has an important role, describing the challenges of learning

especially from a systemic perspective, and systems thinking view on learning (as described mainly by Senge, 1990; Sterman, 2000; Argyris & Schön, 1996) has been utilized also in the later articles as one of the studied theoretical approaches. The networking aspect of the thesis research has been also briefly mentioned in this study to bring more complexity and challenges for learning because of the increasing number of participants, growing distance and problems of feedback. The main results and contribution of Publication I to the research questions are firstly, identifying systems thinking as one relevant viewpoint for innovation-related learning and secondly, classifying the learning challenges in innovation especially from systems thinking perspective. The following publications discuss the learning phenomenon from the point of view of innovation networks in more detail.

5.2 Publication II

The second publication, *"Learning in networks: an exploration from innovation perspective"* presents multiple theoretical views on learning that are relevant and interesting for networked innovation activities based on a literature review, and their implications for learning in and by innovation networks. The selected views also represent diverging approaches to provide a many-sided picture of the studied phenomenon and implications from several perspectives. The learning challenges and the implications have been studied on inter-organizational and network level, considering especially the challenges in innovation, and based on a systems thinking approach, which focuses for example on double loop learning and the role of feedback as an enabler of learning (Sterman, 2000). The article widens the perspective of the first publication to a new context and applies the general theories of organizational learning presented in the literature to the inter-organizational and network level learning in innovation.

The publication shows the potential of using multiple approaches to learning to efficiently take advantage of it. There is a vast amount of different learning models and approaches available in the literature, but the ones selected to the study represent perspectives that have recently gained increasing attention in the areas of innovation and networks and have been researched and referred to by many different authors. Other possibly interesting theoretical approaches not included in the study are for example communities of practice (CoP), co-creation of knowledge in social networks, virtual learning etc.

In the thesis, the role of this publication is on a conceptual level to give theoretical understanding of the different significant learning perspectives and their implications to inter-organizational learning in networks. The challenges of learning are discussed especially from an inter-organizational perspective, and the results of this publication, the implications for learning from several perspectives, give a base for the development of solutions in the form of organizational practices for supporting learning. Using a wide variety of perspectives enables a many-sided view of the studied phenomenon, learning in networks. Inter-organizational learning and its challenges are considered especially in innovation context. The study goes beyond a traditional literature review by exploring the practical implications of each studied learning perspective specifically to inter-organizational learning and networked innovation. Extending the views and combining these areas allows new insights and a broader view of the subject of learning, but at the same time focuses it better on innovation-related learning in networks. The main contribution of Publication II is identifying several significant learning views for networked innovation.

	Publication I	Publication II	Publication III	Publication IV	Publication V	Publication VI
Title	*"Systems thinking and learning in innovation process"*	*"Learning in networks: an exploration from innovation perspective"*	*"Views and practices on inter-organizational learning in innovation networks"*	*"Challenges and practices for learning within and by innovation networks"*	*"Contribution of virtual teams to learning and knowledge generation in innovation-related projects"*	*"Effect of virtual teams for learning in innovation: contributing and inhibiting factors"*
Objective	To discuss the relationships of systems thinking and learning in the context of innovation process.	To study the literature of learning, innovation and networks particularly from the point of view of learning in inter-organizational networks.	To analyze the different learning approaches and evaluate their suitability in various situations and conditions of innovation networks.	To produce a more detailed picture of inter-organizational learning, especially network learning in innovation activities through empirical data.	To analyze how a virtual team may facilitate or prevent learning, knowledge generation, and ideation processes in New Product/Service Development (NP/SD).	To study how the adoption of virtual teams offers benefits and challenges for learning in innovation context and analyze their importance in practice.
Primary level of the learner	Individual / group / organization	Organization / network	Organization / network	Organization / network	Group / organization	Group / organization
Data / methods	Literature review	Literature review	Literature review	Literature / empirical theme-based interviews	Literature review	Literature / empirical theme-based interviews with a questionnaire
Results	Preliminary framework for categorizing learning challenges from a systemic perspective	Identifying from the literature and evaluating several viewpoints on learning that are significant for inter-organizational learning and innovation	• Evaluating the suitability of the theoretical learning views to various situations in innovation • Suggesting practices supporting each learning view	• Categorizing of learning challenges • Identifying practices for learning on a network level	• Developing a virtual team life-cycle model based on the literature from a learning perspective • Framework of challenges and benefits of virtual teams for learning combined to the life-cycle	Identifying the most important learning challenges / benefits that virtual teams have
Role in the thesis	Background on the nature of innovation process & learning challenges	Understanding of significant views of learning for networked innovation	Deepens the understanding of the learning views and how they relate to a theoretical framework of learning types.	Understanding of the practices related to learning views and of the learning challenges in real innovation networks	Understanding of virtual teams and their effects on learning in innovation	Understanding the priorities of the learning challenges and benefits in virtual teams in practice
Main contribution to thesis research questions: - concepts - challenges - solutions	Learning challenges categorized from systems thinking perspective	Identification of significant learning views for networked innovation	Practices for supporting learning from different theoretical viewpoints based on the literature	Concepts of different learning views in theory combined with empirical findings	Virtual teams and their tools as a possible organizational and technical solution for learning in innovation	Challenges for learning in virtual teams studied in practice and prioritized

5.3 Publication III

The third publication, *"Views and Practices on inter-organizational learning in innovation networks"*, continues the thoughts presented in the previous two articles and expands the study conceptually firstly by positioning the previously identified learning approaches into a framework of learning types by Crossan et al. (1995). The study also presents ideas for learning practices related to the various theoretical approaches. This highlights the potential of supporting and utilizing learning from many different perspectives, especially in inter-organizational and network context.

The study discusses further the similarities and differences of each learning approach and how can different perspectives on learning be utilized in different situations related to innovation activities. The paper continues the discussion on different learning approaches relevant for innovation and networks. The main contribution of Publication III to the research questions is at the level of solutions: the paper presents ideas on the suitability of different learning views and typical learning practices for various situations in innovation activities.

5.4 Publication IV

In the fourth publication, *"Challenges and practices for learning within and by innovation networks"* the emphasis is specifically on providing empirical views on the challenges and practices related to learning in innovation networks, since the existing research does not provide many empirical examples of inter-organizational learning practices, especially on network level. The paper builds on the previous articles, now giving concrete examples of the challenges and practices as experienced by the participating network members. The research utilizes empirical data from in-depth interviews and the content analysis method to classify the meanings presented into different categories or levels of challenges and practices encountered.

The empirical interview data highlights the organizational level of learning although all the organizations operate in networks. The need for network level coordination and learning practices for learning as a network was acknowledged, but the current practices focused more on the organizational level. The theoretical background of the article is based on inter-organizational learning views, and the study is partly conceptual in making connections between the theoretical concepts and practical views expressed by the interviewees.

The identified challenges of learning from the empirical interviews have been categorized according to the levels of inter-organizational learning: organizational, dyadic and network levels, to enable better identification of the issues related to the network level learning. As solutions, the study presents a classification of empirical practices that were identified to support learning from different theoretical viewpoints. The main contribution of Publication IV for the research is combining the theoretical learning views and concepts to empirical findings, and answering all the research questions from an empirical point of view.

5.5 Publication V

The fifth publication, *"Contribution of virtual teams to learning and knowledge generation in innovation-related projects"* changes the perspective of the study towards a more practical orientation in organizing innovation activities. It continues to discuss learning in networked innovation, but from an internal network perspective, using virtual teams as an example of practical organizational form. Based on an extensive literature review, it discusses the role and potential of virtual teams to support or limit learning in innovation, and what kind of learning challenges or benefits are there when utilizing virtual teams in innovation projects.

As a starting point for the analysis of the challenges and benefits, the paper presents a novel life-cycle model of virtual teams from the point of view of knowledge generation and learning, and later connects the phases of the life-cycle to the benefits and challenges of learning. This enables the identification of the significant supporting and challenging factors for learning in each phase of the virtual team life-cycle. The paper provides insights on the role of virtual teams in distributed innovation activities and on the development phases of the team as well as the possible learning challenges and support for learning in innovation. The main contribution of Publication V is identifying virtual teams and their tools as a possible organizational and technical solution for learning challenges in innovation.

5.6 Publication VI

The sixth and final publication of the thesis, *"Effect of virtual teams for learning in innovation: contributing and inhibiting factors"* looks more in detail on the conceptual level at the constructs developed in the previous article related to the challenges and benefits of virtual teams to learning. The previously developed life-cycle model and the framework of challenges and benefits are evaluated and developed further. The paper achieves this by prioritizing the importance of challenges and benefits for learning and the life-cycle phases from a practical point of view, based on qualitative managerial interviews. In addition, the study gives the reasons for the prioritization, why certain challenges and benefits are seen as important.

The identification of the most important challenges and benefits for learning helps managers of distributed virtual innovation teams to focus on the significant factors when developing learning in the innovation network. The paper presents virtual teams as an organizational form and the technical tools that they use as potential solutions to the learning challenges. The level of analysis is on team level internal networks, which can also be seen as separate organizations due to the distance between them, although the studied teams were internal development teams within the studied organizations. The main contribution of Publication VI to the research questions is related especially to the challenges of learning and solutions for supporting learning: the challenges and benefits that virtual teams pose for learning are prioritized from practical perspective, identifying the most important issues to concentrate on.

6 Discussion and Conclusions

Learning has been recognized in the literature as an important process for innovation, as well as for networks. This research has combined these three areas and studied the intersection of inter-organizational learning in innovation networks, especially concentrating on network-level learning. The study has focused on looking at the views and concepts, challenges and solutions related to the learning phenomenon both from a theoretical perspective and in practice. In the final section of the thesis, the contribution and implications of the research are discussed and the research is evaluated. Also some ideas for further research are presented.

6.1 Contribution and implications

The main result of this thesis is new knowledge about inter-organizational learning, especially network level learning in innovation networks. The contribution of the thesis is based on the combined results of Publications I-VI and on the material presented in the introduction part of the dissertation. In the following, the contribution is discussed first from the point of view of the existing literature, then from practical managerial perspective and divided according to the themes of the research questions: the views and concepts of organizational learning, and the challenges and solutions for learning in and by innovation networks.

Using many versatile perspectives from the learning literature in Publications I-IV and also combining virtual teams to the study in Publications V and VI allows a many-sided, more profound and wider view of the learning phenomenon and a possibility to evaluate and integrate the central ideas of each approach, than restricting the study to one existing theoretical framework. Also, using multiple views allows to emphasize the characteristics of each view and evaluate the relative importance and suitability of the various views to networked innovation environment and to network level learning based on the literature and by showing for example in the empirical research which theoretical views were more emphasized in practice than the others. Combining different views is also seen as an appropriate strategy because of the novelty of the studied area, since there is not much existing research especially on network level learning in innovation. Thus, in this research it is seen as a more important objective to extend the existing theories of organizational learning to the network and innovation context as broadly as possible by combining many different approaches, than providing a deeper level of detail from only one or a few theoretical perspectives. So far, similar research where multiple perspectives on this topic would be combined and utilized, has not been found elsewhere.

6.1.1. Contribution to literature

The domain of this research is comprised of three areas, which can also be seen as the literature bases for the study: innovation, networks and learning. The research focuses attention to issues that have been scarcely researched by combining research on inter-organizational and network learning with the research on innovation management. In more

detail, the focus area is defined as the intersection of these broad topics, as inter-organizational learning in innovation networks. This also positions the research in relation to the existing literature, taking part in and providing knowledge for a) the discussion on inter-organizational and network learning (e.g. Knight, 2002; Knight & Pye, 2005; Jones &Macpherson, 2006) on one side and b) the discussion of networked innovation (e.g. Miller & Morris, 1999; Calia et al., 2007) on the other. The new insights of this research come from combining these areas of research and literature, providing new knowledge on inter-organizational learning particularly on network level related to innovation networks, and including the significant process of learning in and by networks into the discussion of innovation networks and their management as a possible source for competitiveness. Learning in innovation context has specific challenges that have been studied in this research, and especially when the current practices for innovation emphasize the need for networking which further increase the challenges and complexity, a multi-perspective study on learning in networked innovation can provide new useful knowledge to all three areas. Studying only two of these areas together, like innovation networks or learning and innovation in general, has been already extensively done by other researchers, but the novelty in this research comes from the combination of all the three, which provides new insights to both learning and innovation networks.

Views and concepts on learning

As an answer to research sub-question 1 on the interesting viewpoints and concepts on organizational learning, six divergent learning views were identified and utilized in the study: the conversion of explicit and tacit knowledge, learning for exploitation and exploration, absorptive capacity, organizational memory, systems thinking, and dynamic capabilities. They each provide insights for networked innovation from a specific point of view and also complement each other. The systems-thinking related concepts and view on learning acted in this research as a basis for studying inter-organizational learning in innovation context, which is by nature a complex process. Especially the deeper, so-called double loop learning which is based on questioning existing values and norms behind the actions was seen as significant for innovation, when the aim is to produce radically new ideas. The research also identified several viewpoints on learning from literature which were evaluated as interesting and useful from the point of view of networks and innovation. These diverse approaches were selected to enable building a more versatile picture of the learning and to enable implications from several different directions by combining and evaluating the views together, which has not been done in earlier research. Because innovation and development work particularly in networks between multiple partners is such a many-sided and complex process and learning in this context has special challenges, also multiple learning views are needed to cover a wider range of situations and to offer insights to solve the challenges. The concepts of different learning views in the literature were also reflected with empirical findings about practices related to learning, focusing on learning by multiple partners as a network to answer to the need of empirical research on network learning (Knight & Pye, 2005).

Concerning the part of study on virtual teams and how they affect the learning within the team and also from the team to the organizational level, the focus was to enhance knowledge on virtual teams from the learning point of view, especially in the networked, distributed innovation context. In the research, a novel model of virtual team life-cycle stages from the

learning perspective was created based on earlier research, and also evaluated in practice. This gives a possibility to focus on the most influential stages of the life-cycle when developing the supporting practices for the virtual team.

Challenges

To answer sub-question 2 on the learning challenges, the challenges for learning were identified and categorized through several frameworks and utilizing different learning views. First, the learning challenges in innovation were categorized from a systems thinking perspective, putting emphasis on the dynamic complexities involved in innovation and on the special features of the innovation process. The identified learning challenges were related to for example the complexity of the environment and getting feedback. Next, the learning challenges and their implications were analyzed in the inter-organizational network context especially in innovation, based on the literature. The challenges were also identified and categorized in practice in the empirical research according to the level of the learner, allowing a deeper look into especially network-level learning challenges. Finally, the learning challenges were also studied in the context of virtual teams, where the developed framework or categorization of both the challenges and benefits of virtual teams to learning was further evaluated in practice and the challenges and benefits were prioritized according to their perceived importance.

Solutions

As an answer to sub-question 3 on the possible solutions to support learning there were multiple approaches and practices. For example, systems thinking ability and methods and tools based on it were identified as one possible solution for overcoming the learning challenges, because in a networked environment it allows a larger view of the situation and gives understanding of the complexities and interactions, as well as helps the identification of the network partners and their roles. Implications of multiple learning views for networked innovation, in addition to systems thinking, were also identified, and diverse practices for supporting learning from different theoretical viewpoints were suggested based on the literature and also identified in the empirical part of the study based on the existing practices for learning in the studied innovation networks.

The use of virtual teams and utilizing their tools to support learning are seen in this study as a possible organizational and technical solution for learning in innovation. In organizing innovation collaboration through virtual teams, virtuality allows to solve many of the challenges of learning related to innovation and offers support to learning, but it also has additional challenges due to distance between the collaborating parties.

6.1.2. Practical implications

Many of the results achieved in this research have practical implications for managers especially in innovation networks. In general, the results of the thesis show the need to support learning more systematically and improve the learning processes in practice, to be able to better take advantage of especially network level learning. The results of the thesis tell about the nature of learning in innovation-related co-operation networks, and about the obstacles and possibilities that it has.

Utilizing multiple learning views in practice

The implications of including different inter-organizational learning perspectives to innovation activities are significant, because effective learning can enable improving the speed and flexibility and time-to-market in innovation, which in turn can improve competitiveness of the networks and the organizations within the networks. The viewpoints identified by the literature studies and combining their implications to inter-organizational learning and network learning in innovation can facilitate learning effectively. In the empirical research in innovation networks, especially the practices related to the learning views of organizational memory, tacit and explicit knowledge and explorative and exploitative learning were emphasized and easily identified. On the other hand, the interviewees said that practices related to some other learning views such as absorptive capacity or dynamic capabilities were difficult to identify, which may be due to the complexity of the abstract concepts and difficulties in relating them to practice. In general, learning was not systematically supported in the daily operations, especially on the network level, but the importance of learning to competitiveness and to future strategies was acknowledged by the interviewees.

First, innovation managers need to acknowledge the complexities of their operating environment, including the network they are part of, and the effect of these complexities on challenges for learning. Systems thinking and the methods based on it can help in creating common understanding of the dynamic complexity in the network. The results of the thesis give ideas on how to support learning in a complex innovation environment both with organizational practices and technology solutions, utilizing different theoretical views on organizational learning. Some practical ways to support learning, such suggestions for managerial practice according to different views on learning, are mentioned in the publications.

Second, the improvement needs in network level learning were seen as an important development area, and the importance of learning on the network level needs to be highlighted in the organizations. This means setting objectives and planning the support systems and practices for learning between multiple organizations, not only within own organization. Another issue here is the importance of integrating many versatile approaches of learning when planning and implementing practices and tools, and evaluating their suitability for various possible situations. The tables developed in Publications II-IV in this study regarding the learning approaches and their implications to networked innovation and learning practices can be used as checklists to evaluate the current situation in organizations and in developing their practices further.

Learning and managing virtual teams

Virtual teams were identified during the research process as a significant area for this research from the practical perspective as many innovation projects are organized as virtual teams, and because of the similarities that distributed working between team members even within one organization has to inter-organizational collaboration. From the point of view of managing virtual teams, the research offers several suggestions on how to support learning in virtual collaboration, and which issues and phases of the team life-cycle are the most

significant from the learning point of view. Based on the literature, the last stages of the lifecycle, finishing or disbanding the team has been highlighted as the phase where the learning is shared, but in this research the results of the empirical study based on the interviewees' experience emphasized the starting and the actual working phase of the team as the most significant phases for learning. Based on this, the managers of virtual teams should take the effective learning of the team and ways to share it to the rest of the organization as one of the objectives of the team, and plan and develop practices to support learning already from the early stages and during the whole life-cycle.

The tables developed in Publications V and VI on factors supporting and limiting learning in virtual teams and the evaluation of their importance can be used for example to evaluate the current situation and to identify the important issues that need attention. The results of the research will be valuable in planning the organization of innovation activities in partner networks and they help in supporting learning in innovation process between organizations. With these results, it will be also possible to analyze networked innovation activities from the viewpoint of inter-organizational learning.

6.2 Evaluation of the research

Due to its nature and choices related to the approach, qualitative research is hard to evaluate with the traditional validity and reliability concepts used in quantitative research. Denzin and Lincoln (2000) propose the following criteria for the evaluation of qualitative research: dependability, confirmability, credibility and transferability. In addition to these aspects, the limitations of the research are discussed below.

6.2.1 Dependability

Dependability evaluates the quality of the research process, and comes close to the concept of reliability. Issues such as the researcher's position, the documentation of the process, and the logical and systematic progress of the process are included.

Documentation of the research process and its stages was done systematically in the form of meeting notes and a research diary kept by the researcher. The research process itself was a joint effort of several researchers, and especially in interpreting the empirical data this helped in avoiding too much subjective views and bias. For the empirical part of the research, all the interviews were recorded and transcribed. The interviewees also had a chance to read and comment a draft version of the publications, and received the final version of it.

The research process, as natural for qualitative research, was not linear, but included some re-evaluations and definitions made on the way, for example to include the area of virtual teams to the study as it became obvious that this is a significant development in organizing networked innovation activities in practice. The structure of the thesis as an article-based collection as well as the qualitative research approach give flexibility needed for this kind of decisions, as long as the overall objective of the research is followed.

6.2.2 Confirmability

Confirmability evaluates the sufficiency of the research process and also that the research findings are based on the data. Many views on the research topic were included in the thesis, as a versatile picture of the phenomenon was pursued. Although all the publications have their own specific research foci, in connection with the introduction of the thesis they provide new insights on the research questions.

The data source in most of the publications in this thesis was literature on organizational and inter-organizational learning, organizational networks and innovation management. The literature reviews were extensive and covered a wide range of research fields from organizational psychology to computer science, which allows building on earlier research and confirming findings. The process of the literature reviews was mainly heuristic, and a more structured, analytical approach in the literature search and selection would probably have improved the coverage. The content of the articles could have also been analyzed with for example the qualitative content analysis process used with the interview data. A more systematic, even quantitative analysis of the literature could have been done in the beginning by for example selecting only a certain number of journals to the research based on the ISI database rankings (which journals have published most on the topic of the research, or which have high impact factors). On the other hand, this could have excluded some interesting and relevant journals and would have provided only a snapshot of the current situation. Furthermore, because of the article-based structure of the dissertation, the research process has advanced part by part in several stages, and this kind of selection process could have been difficult to carry out and keep updated in practice. The literature reviews allowed building background knowledge on the topic, but also in their part provided answers to the research questions, especially to question 1 on the relevant viewpoints and concepts of learning.

In the empirical studies, the findings are based on several sources: interviews, public material and literature, which improves the confirmability. Despite the limited number of selected cases and interviewees, saturation of the data was achieved. By concentrating on a small number of cases, it was possible to provide more in-depth, rich descriptions of the cases, and also the expertise of the informants was valued over the quantity of interviews. The study provides possibilities for naturalistic and analytical generalization of the results (Stake, 2000), not statistical generalization. This means that the results can be generalized to a broader theory and used in the context of the specific reader based on the thorough descriptions of the cases.

6.2.3 Credibility

Credibility evaluates the truthfulness and accuracy of the description of the research subjects. The views of the researcher must follow the perceptions of the research subjects, for example interviewees.

In the empirical studies included in the thesis, Publications IV and VI, the primary data came from interviews which were recorded and transcribed afterwards, and the interviewees had a chance to comment on a draft of the publications. As a secondary data source for the empirical part, also publicly available material about the organizations such as internet-

pages, annual reports etc. were used to complement the case descriptions. Because the interview data was analyzed with qualitative content analysis, the same text analysis method could have been used also for the secondary material to look for additional meanings concerning the research questions, but this was not considered necessary as the material was originally produced by the organizations for other purposes, and it had no direct link to the research topic.

6.2.4 Transferability

Transferability evaluates the possibility of transferring the research findings to another environment, or the usability of the findings in further research.

The transferability of the empirical research results is limited because of the research setting, and any generalizations cannot be made directly based on the research results on a specific case analyzed. However, as a whole the research results, the developed tables and classifications, and the implications and solutions suggested are useful and applicable to many organizations. The transferability varies between the type of results achieved: for example the results on learning challenges and supporting factors of virtual teams for learning should be easily transferable, whereas the implications of the included theoretical learning views in practice are more context-dependent and probably not easily transferable. In each case the situations are different and each organization and network should first analyze their particular situation. Several directions for further research are identified and discussed in more detail in section 6.3.

6.2.5 Limitations

The aim was to provide new insights on a broad topic by combining several viewpoints from the literature. This allowed a versatile picture of the inter-organizational learning phenomenon in innovation networks, the identification of special features of each studied learning view and diversified implications for innovation networks based on those. On the other hand, it has limited the depth of the research compared to choosing just one theoretical starting point, and also made the operationalization of the concepts for empirical research challenging.

Another limitation of the study is the basic assumptions made in the beginning of the research concerning the nature of learning and the selected networks. Learning is mostly discussed in the thesis as a positive phenomenon, although the link of learning to performance is not so clear and has not been included in the discussion of this study. The possible negative effects of learning especially between organizations and in networks are acknowledged as well, including threats such as knowledge spillovers, learning wrong things, the challenges of unlearning etc. The chosen network type, strategic or purposeful business to business collaboration networks in the area of innovation, and the empirical research carried out within one industry might also limit the applicability of the research and unnecessarily restrict the potential interested audience.

Additionally, the level of analysis and interpretation in this research has been the level of a network or an organization (or a group within an organization), not individual. Other

possible analysis levels, which would have led to different insights and understanding, would have been for example a project level or inter-project level. However, there is substantial on-going research on project level learning and related issues, so the research task here was defined differently.

6.3 Further research

This research will hopefully encourage also other researchers to explore the area of learning in and by innovation networks. Several important directions for continuing research based on this study can be identified. First of all, the *concepts related to inter-organizational and network learning* are complex and need further clarification. On the conceptual level, also the *links and applicability of organizational learning frameworks to inter-organizational and especially network level learning* should be studied further. The detailed *operationalization of the concepts could better allow also broader empirical research*, which should be carried out in different industries.

Although some tools and practices to support learning were identified in the research, further research could also be conducted about the *practical tools to support learning in and by innovation networks*, for example using simulations and games. These have been already widely used by some organizations mostly internally, but are not yet very common in collaboration. Some research on this area has been done also in inter-organizational settings, but from a different perspective concentrating on the improvement of co-operation and coordination, not concentrating on network learning in particular.

In the future, one possible direction for further research based on the findings of this study on different learning views and their characteristics and applicability to innovation network context could be also *quantitative studies of the network learning phenomenon related to innovation*, when some of the learning-related factors that could be used as quantified factors are identified. *A detailed analysis of the learning process within and by networks, especially in innovation, and the factors affecting it is still to be done.* Also the *linkages of the learning processes and innovation processes* in general and in different types of innovation activities is an interesting question for further study. This research has provided a basis for further detailed analysis by identifying some important viewpoints of learning from the point of view of innovation networks. An interesting starting point would be *to combine different views on learning to different stages of the innovation process*, to study for example which type and approach of learning would be most beneficial and should be taken into account and supported in the different stages of the innovation process and the collaboration relationships.

There are numerous *factors that can affect the phenomenon of inter-organizational learning in innovation networks and how it takes place*, such as the objectives of the collaboration, the desired output of the collaboration, the type of the innovation and the stage of the innovation process and the stage of the relationships between the network members, and the definition of roles and responsibilities. These factors should be analyzed further and more systematically to allow in-depth understanding of the inter-organizational learning in networks with multiple partners. Especially when the organization of innovation is increasingly virtual, either internal or external networks, the understanding of shared knowledge creation and learning together as a network should be valuable.

The current innovation models are designed for internal use of the organizations and mostly presented as a linear continuum, with possibly some feedback loops or connections outside the organization. In practice, the collaboration in innovation is much more versatile, and the actual development projects do not progress linearly, but all the aspects related to the development process, the collaboration network and learning are intertwined and in constant evolution. This means that *more dynamic models of the innovation process and the factors related to it should be created*, that take into account the changes in the network and in the learning process during the collaboration. The innovation process itself can be defined as a learning process, since both learning and innovation are by their core nature processes that are based on change, but the aims of innovation and learning differ and also the practices to achieve the aims are separate, although one can support the other.

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APPENDIX I a
Interview introduction letter in publication IV (a translation from Finnish below)

Hei,

Olen tekemässä väitöskirjaa Lappeenrannan teknilliselle yliopistolle organisaatioiden välisestä oppimisesta innovaatioverkostoissa, jotka määrittelen monen osapuolen yhteistyösuhteiksi joiden tavoite on luoda uusia tuotteita, palveluita ja prosesseja.

Sain [henkilöiden nimet] tiedon, että te voisitte olla kiinnostunut aiheesta ja mahdollisesti voisitte osallistua tutkimuksessa toteutettaviin haastatteluihin. Tutkimuksessa on tällä hetkellä kaksi eri linjaa: ensimmäisessä tutkitaan oppimista ja sen tukemista innovaatioverkostoissa yleisellä tasolla, ja toinen kohdistuu virtuaalitiimeihin ja siihen miten ne vaikuttavat oppimiseen. Virtuaalitiimit-osuuden osalta olen ollut jo aiemmin yhteistyössä [henkilön nimi] kanssa, mutta otan mielelläni vastaan kommentteja ja mahdollisia kontakteja myös teiltä.

Tutkimuksessa on tarkoitus haastatella muutamia yritysten verkostoja, jotka tekevät yhteistyötä tuotekehitykseen tai muuhun kehitystoimintaan liittyen, niin että mukana on samasta verkostosta useampi yritys. Haastattelut innovaatioverkostojen oppimiseen liittyen on tarkoitus toteuttaa noin puolentoista tunnin mittaisina yksilöhaastatteluina maaliskuun loppuun mennessä. Olisi erittäin mukavaa jos teiltä löytyisi aikaa haastattelulle lähiviikkoina.

Haastattelussa käydään keskustelunomaisesti läpi mm. seuraavanlaisia teemoja: yhteistyöverkoston toiminta ja toiminnan koordinointi yleensä, verkoston oppiminen innovaatiotoiminnassa ja eräät oppimiseen liittyvät teoreettiset näkökulmat, sekä oppimisen liittyminen strategiaan ja kilpailukykyyn. Tutkimus tehdään anonyymisti, joten vastaajia tai yrityksiä ei voi aineistosta tai raportista tunnistaa. Tutkimus raportoidaan ensimmäisessä vaiheessa konferenssipaperissa, joka julkaistaan kesäkuussa Ranskassa.

Vastaan mielelläni, jos teillä on lisäkysymyksiä, ja toivottavasti voimme palata asiaan pian!

Hannele Lampela
_____
hlampela@lut.fi
+358-40-7380238

Hello,

I am writing my doctoral thesis for Lappeenranta University of Technology on inter-organizational learning in innovation networks, which I define as co-operation between multiple partners with the aim of creating new products, services or processes.

I have received information from [person's name] that you might be interested in the topic and possibly would be able to participate in the interviews. The research contains two lines: first on learning and supporting learning in innovation networks and second on virtual teams and their effects on learning. Concerning the part of virtual teams, I have co-operated with [person's name], but I'll be happy to receive also your comments and advise on possible contacts.

The aim is to interview company networks which co-operate in product development or other development work, so that there are several companies and interviewees from each network. The interviews on learning in innovation networks are individual interviews of about 1,5 hours planned to be conducted by the end of March. I would be grateful if you can find the time for an interview in the coming weeks.

In the interviews, the following themes are discussed: the functioning and coordination of the network, network learning and innovation activities, some viewpoints on learning, and the connection of learning to strategy and competitiveness. The research is anonymous, so individual respondents or companies cannot be identified in the data or the final report. In the first stage, the results are published as a conference paper which will be presented in June in France.

I will be happy to give you any further information, and hopefully we can be in contact soon!

Hannele Lampela
_____
hlampela@lut.fi
+358-40-7380238

APPENDIX I b
Interview themes in publication IV (translated from Finnish)

Interview on inter-organizational learning in innovation networks

1. Background information
- Interviewee and organization

2. Network collaboration
- Objectives, coordination, roles etc.

3. Learning and innovation networks
- Interviewees own definition of learning, objectives for learning, support for learning in the network, roles and responsibilities, challenges for learning, risks or threats

4. Diverse viewpoints on learning, how are they manifested in practice on the network level
- Organizational memory (databases, other information systems, documents, reporting, processes, routines, structures)
- Absorptive capacity (earlier knowledge in relation to network partners, similarity or differences)
- Knowledge conversion, tacit and explicit knowledge (especially sharing tacit knowledge in a network)
- Explorative / exploitative learning (balance of acquiring new knowledge vs. utilizing existing knowledge, what are the main channels and means)
- Systems thinking (significance of feedback processes, questioning existing operation models)
- Dynamic capabilities (identifying core competencies and resources together with partners)

5. Significance of learning to competitiveness
- Future strategy, development needs

6. An example situation of network level learning
- Interviewee's own description of a learning situation that affected the network

Finishing: Anything else related to the research topic? Anybody else you could recommend as an interviewee?

APPENDIX II a
Interview introduction letter in publication VI

Hello,

You have been participating into one of our Virtual Team Leadership (VTL) Programs held at [the company name]. In developing our virtual working further we are currently doing research on "Contributing and inhibiting factors for learning in virtual teams". The research will be completed in cooperation with Lappeenranta University of Technology. Therefore we are looking for interviewing persons among you, who are currently having experience on working in virtual teams and who are surely familiar with the challenges/benefits of virtual working.

We would appreciate your valuable help in more in-depth understanding of the challenges of virtual working and also guiding our further development of [the company name] Virtual Tools. This research also provides valuable background for developing our Virtual Team Leadership (VTL) Program further. The research will be conducted during spring 2008 in Finland and in France, and the results will be reported in a conference paper that will be published later this year.

If you are interested in participating the interview, please send an email to Lappeenranta University of Technology researcher Hannele Lampela (hannele.lampela@lut.fi) for agreeing on your interview time. The deadline for responding by email is on **Friday, March 14**.

The interviews will be held in March/April, when they are convenient for you, and the duration is approximately one hour that could be carried out either virtually or face-to-face (to be agreed, to take place in Finland). The interview results will be anonymous, so in the final results the respondents will not be identified.

Thank you for your co-operation already in advance!

Regards,

[The Company Representative]   Hannele Lampela
Manager   Researcher
                                                Lappeenranta University of Technology

APPENDIX II b
Interview themes in publication VI

Interview guide on manager and participant experiences of how virtual teams limit or support learning (in new product / service development (NP/SD))

1. Experiences from the last time when was involved in a VT
o   What happened during the last time you were involved in VT?
o   What kind of virtual team are/were you involved in
o   What kind of project, which purpose, outcome
o   Dynamics of the development, life-cycle

2. Life-cycle of VTs
o   Which phase of the life-cycle is seen as most important from learning point of view? Why is this?
=> The earlier developed life-cycle model introduced, development phases 1-5

3. Learning (in NP/SD)
o   How does learning generally happen? (levels of learning from group to inter-organizational level, not only individual)
o   Significance of learning for success (in NPD?/international/interorg. teams)
o   Examples of learning situations (in NPD?/ international/interorg. teams)
o   Tools and practices that are used to support learning?
o   Learning and Virtual Teams
                 Any special features?

4. Factors limiting/ inhibiting learning when using VTs
o   Ideas or experiences?

5. Factors supporting / contributing to learning when using VTs
o   Ideas or experiences?

6. Questionnaire: Evaluation of the importance of limiting and supporting factors for learning, in different life-cycle stages of VTs (questionnaire on the next pages)

7. What are the 3 (5) most important limiting and supporting factors for learning? Why?

8. Other comments / development needs?

APPENDIX II c
Questionnaire items in publication VI

Benefits/contributing factors	In which **phase of the VT life-cycle** primarily (1 = preparation 5 = finishing)	**Importance for learning** (in NPD/NSD when applicable) (1-5 scale, not at all significant - very significant)
1. Group has best available expertise and knowledge		
2. Heterogeneous backgrounds, increased creativity		
3. Fast reactions to changed customer needs, enabling fast project launch if necessary		
4. Easier conflict resolution through anonymous ICT tools		
5. Varied backgrounds, experience and added creativity for sharing and defining new working processes and selecting new technologies to support them		
6. Understanding and learning about local customer needs and solutions		
7. Cognitive differences may also help to question self-evident issues, leading to learning		
8. Added creativity for product concept and architecture development		
9. Regular and frequent inter-team communication and feedback through ICT		
10. Utilizing ICT tools for team training		
11. Fast reacting to changed customer needs reducing lead-times and time-to-market		
12. Changes are fast to communicate		
13. Potential to enlarge the scope of experiences and cognitive maps regarding opportunities		
14. Possibility for arranging learning –related review meeting faster		
15. Easier to share critical thoughts and experiences without too much personalization		
16. Use of short, clear expressions to reduce language misunderstandings and media constraints		
17. Better preparation for meetings enabling learning		
18. Possibility for systematical document sharing and storage in one place		

Questionnaire items in publication VI

Limitations / inhibiting factors	In which **phase of the VT life-cycle** primarily? (1 = preparation 5 = finishing)	**Importance for learning** (In NPD/NSD when applicable) (1-5 scale, not at all significant - very significant)
1. Lacking and slower trust development		
2. Faulty first impressions and stereotypes		
3. Challenge of recognizing the expertise of others (who knows what)		
4. Recognizing and challenging own assumptions about others' expertise		
5. Limitations in sharing earlier development project experiences		
6. Language misunderstandings		
7. Difficulties in creating and explaining new ideas		
8. Limited understanding of others' mental models		
9. Cognitive barriers limiting information exchange and learning		
10. Conflict situations reducing trust and limiting information exchange		
11. ICT / communication technology selection limiting learning		
12. Norms for using ICT as a limiting factor for learning		
13. Learning time for new tools		
14. Challenge in unlearning previous experiences		
15. Ensuring common understanding		
16. Limited utilization of the creativity potential due to ICT restrictions		
17. Lack of informal meetings		
18. Maintaining a synergy and continuous information flow		
19. Reduced ability for finding solutions to complex conflicts		
20. Limited possibility for face-to-face meetings to share experiences and learning		
21. Limited readiness to talk about problems and improvement opportunities (due to e.g. culture or used technology)		
22. Need for more versatile team leader capabilities		
23. Formation of sub-groups within the team based on language skills		
24. Failure to understand the roles of different tools		
25. Time constraints due to unrealistic project planning and limited motivation / commitment		

Part II

Publications

Publication I

Systems thinking and learning in innovation process

Hannele Lampela* and Hannu Kärkkäinen

Department of Industrial Engineering and Management,
Lappeenranta University of Technology,
P.O. Box 20, FIN-53851 Lappeenranta, Finland
Fax: +358-5-621 2667   E-mail: hannele.lampela@lut.fi
E-mail: hannu.karkkainen@lut.fi
*Corresponding author

Abstract: The success of a company is increasingly dependent on the innovations and new knowledge it can create. The growing knowledge-intensiveness of many industries emphasises the significance of the creation of new knowledge and organisational learning. Learning has become more important than ever before, when companies try to find the fit between their operations, their products and the changing business environment. In the context of learning and knowledge creation, systems thinking is currently widely recognised as an area of growing importance particularly within the area of innovation research. Only few papers that dealt directly with this specific issue were found in the current literature.

Keywords: systems thinking; innovation; learning; organisational learning; generative learning; learning barriers; complexity; new product development.

Biographical notes: Hannele Lampela holds an MSc (Econ.) and an MSc (Tech.) Degree from Lappeenranta University of Technology. She has five years experience from Finnish software companies in various positions, and she has been mainly responsible for marketing and customer service development. At the moment she is an Assistant and a Doctoral student at the Department of Industrial Engineering and Management at Lappeenranta University of Technology, and is working with courses on knowledge management.

Hannu Kärkkäinen is a Professor at the Department of Industrial Engineering and Management at Lappeenranta University of Technology in Finland. He received his DSc (Tech) from the Lappeenranta University of Technology. His current research interests include the early-phase management of R&D, knowledge management and decision-making in innovation, customer needs assessment in business-to-business organisations, and the co-operation and value networks in product innovation. He has published a number of refereed international journal papers, as well as books, book chapters and other publications on the above research topics.

1 Introduction

Innovation and product development are considered some of the most essential processes concerning the creation of new knowledge and information in companies. The essence of new product development is in the creation, utilisation and exploitation of new knowledge (Shani et al., 2003).

Product development is also one of the most knowledge-intensive and complex business processes in companies (Eppler et al., 1999). The complexity is added by the vast number of different functions of the organisation taking part in the innovation process, as well as the increasing tendency for inter-organisational networking in product development. The knowledge-intensiveness and the complexity mean that effective knowledge-creation and learning are critically important, but at the same time extremely challenging issues from the perspective of innovation and product development. Therefore, useful methods and approaches, like systems thinking, are strongly needed to support the efficient learning in innovation-related activities, and they need to be studied and applied particularly in the innovation context.

According to Soo et al. (2002), the firm's and individual's ability to absorb knowledge and information is critical to generating a solid base for new knowledge creation. They show that firms that create the most new knowledge are the most innovative. Furthermore, the most innovative companies have the best market share and the best profit performance relative to competitors. A clear correlation between the amount of knowledge creation and the amount of innovation has been noticed.

This paper aims to discuss the relationships of systems thinking and learning in the context of innovation process. The motivation for the study is to create a proposal for a framework that identifies the connections between learning, systems thinking and innovation process, and some of the most essential factors affecting these connections.

The focus of this paper is on systems thinking and on the methods based on it that can be seen important in the innovation process. The research question is, how can systems thinking be applied to support the process of learning in innovation? We study, what kind of connections are there between systems thinking and learning, and how effective learning can be facilitated in innovation process. The study is based on previous literature on systems methodology and systems thinking, learning and innovation processes. Our literature review revealed very few papers discussing particularly the combination of the above issues. The approach of the study is from the viewpoint of learning and knowledge creation. The level of analysis is organisational rather than individual.

2 Complexity and performance

Eppler et al. (1999) evaluate and classify organisations' various business processes from knowledge perspective according to their knowledge intensity and process complexity, demonstrating that knowledge-intensive processes can be distinguished from other business processes through a series of attributes and inherent problems. According to them, product innovation and product development are by far among the most knowledge intensive and complex processes in organisations. This means that they are among the most challenging and critical processes from the standpoint of new knowledge creation and effective learning. Therefore, the issue of learning should be highly emphasised in

the case of innovation and product development both at the individual and organisational level. Knowledge intensive processes generally need a long learning time before they can be mastered.

Complexity in the system can be the result of many things, the most obvious reason being a great amount of possible combinations of parts in the system, for example of factors affecting the decision-making (combinatorial complexity). This kind of complexity problem is, however, easily solved with mathematical optimisation. Other kinds of complexity are behavioural complexity and dynamic complexity, which are much more difficult to define and to solve (Sterman, 2001; Roth and Senge, 1996).

According to Sterman (2000), the most complex behaviours usually arise from the interactions (i.e., feedbacks) among the components of the system, not from the complexity of the components themselves. In the case of innovation, some major components of the innovation system can include the company functions like marketing, sales and product development participating in the innovation definition and development. Also the inclusion of other companies, which is ever-increasingly happening in the course of the current innovation-related networking-trend, can significantly contribute to the complexity in the process.

The need for systems thinking is emphasised as complexity, turbulence and dynamism are constantly increasing in the modern business environment. Systemic, holistic approaches are particularly necessary in the analysis of dynamic and complex network relationships. This is especially relevant in the case of extremely multi-disciplinary and complex tasks like product innovation and new product development that involve a large number of parties from different organisations, hierarchical levels and functional positions with their own opinions, mental models, objectives and company cultures.

According to Sterman (2000), the more dynamically complex a task is, the lower is the performance level of persons compared to their performance potential. This is illustrated in Figure 1 below.

Figure 1   Dynamic complexity and performance level
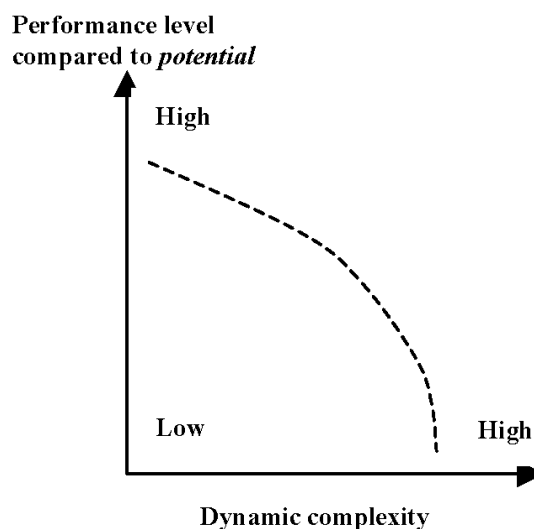
Source: Adapted from Sterman (2000)

3 Organisational learning

In this paper, learning is seen as a process, rather than as an end product. Individuals are seen as actors in the organisation, so individual learning process will not be discussed separately. Organisational learning is a part of a learning organisation; it's the skill of combining the learning of the individuals to achieve the goals, which usually happens through teams that learn.

Organisational learning describes how the organisation creates new knowledge and new skills, for example according to Nonaka and Takeuchi (1995) in a learning cycle by bringing tacit knowledge into explicit, or learning by doing or following best practices. Learning organisation, in contrast, is the common name for all the systems, principles and organisational structures that enable organisational learning.

According to Argyris (1999), there are two situations in which organisational learning can occur. In the first situation, learning means that the organisation achieves its goals better than before, as the planned action and the outcome of the action are in balance. The second situation is when there is a discrepancy between the planned action and the final outcome and learning makes it possible to correct this. Organisational learning happens through the individuals and their learning experiences, but the organisation itself affects the environment of learning and what is perceived as the real problem to be solved or the solutions produced.

Argyris (1977) has also introduced the concepts of single-loop and double-loop learning. In single loop – learning the aim is to correct the mistakes within the organisational boundaries. Learning is mainly seen as means in reaching the goal of effectiveness. In double-loop learning, learning occurs when the organisation and its members are capable of questioning the actions and values they act upon. A similar approach can be found in other organisational learning theory which suggests that there are two learning levels that lead to organisational change: adaptive learning and generative learning. While many organisations deal with change by simply adapting, and while adaptation is a form of learning, it is mainly reactive. In contrast to adaptive learning, generative learning occurs when the organisation is willing to question long-held assumptions about its mission, customers, competitors, and strategy (Argyris, 1977; Senge, 1990).

Importantly, generative learning can lead to radical innovations (McKee, 1992) instead of mere incremental modifications in the products. While learning faster and more effectively than the competitors may be the only source of sustainable competitive advantage in competitive markets (e.g., Slater and Narver, 1995), it is significant from the standpoint of the competitiveness of companies that generative learning can be a potential source of sustainable competitive advantage (Sinkula, 1994; Slater and Narver, 1994, 1995).

Generative learning takes the organisation to the area of new innovations and development processes, although adaptive learning is also part of generative learning, since the new innovations require a skill to see things differently and a skill to see the connections between things that influence the behaviour of the system. This connects generative learning to systems thinking.

3.1   Feedback and learning

Sterman (2000) claims that all learning depends on some kind of feedback, just as dynamics arise from feedback: the dynamics of a system, such as an organisation or product innovation system, arises from feedback processes. This includes that persons making decisions that alter the real world (or their environment) gather information feedback about the real world surrounding them. Using the new information they revise their understanding of the world and the decisions they make to bring their perception of the state of the system closer to their goals. This is illustrated in Figure 2.

Figure 2   Information feedback from decisions in single-loop learning vs. double-loop learning
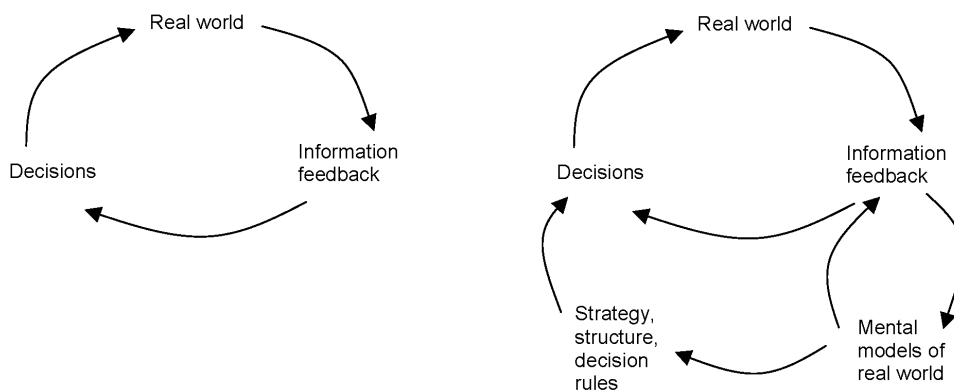
Source: Adapted from Sterman (2000)

The single feedback loop describes the most basic kind of learning. However, contrary to the implications of such learning concept, information feedback is not the only input to our decisions. Decisions are a result of applying a decision rule or a policy to information about the world as we perceive it (Sterman, 2000). The policies are themselves conditioned by institutional structures, organisational strategies and cultural norms, which, in turn, are governed by our mental models. As long as the mental models remain unchanged, we learn by an adaptive way or single-loop learning. This simplistic feedback learning process does not change or affect in a fundamental way to our understanding of the causal structure of a system, or the boundaries seen around the system. Systems thinking is an effective way to improve the learning, as well as facilitate the skills for double-loop learning.

3.2   Significance of learning in innovation

The firms' learning capabilities play a crucial role in generating innovations (Sinkula et al., 1997). In innovative companies especially the double-loop, generative learning ability is more important than elsewhere, since the secret of success is in creating something new, not replicating something that has already been done. Successful innovations require questioning the current ideas and thought patterns behind them.

As described above, the dynamic complexity of innovation- related activities, as well as their knowledge intensity, is relatively high compared to other organisational tasks and processes. This means that there is generally a relatively high need for efficient knowledge creation and learning in innovation compared to other activities. The more

dynamically complex the task of innovation is in an organisation, the higher this need is, as well as the need for useful ways to support effective learning, such as systems thinking. Also the significance of double-loop learning can be assumed to be particularly high in dynamically complex environments and processes.

4 Barriers to learning in innovation

The more dynamic and complex an environment is from the perspective of decision making, the more there exist various potential barriers for learning, and the more difficult it is to learn effectively from the decision a person or an organisation makes. For instance Shani et al. (2003) denote that the upsurge in the amount of knowledge that is readily available to organisational members seems to add increased complexity to the design and management of NPD work.

The learning and the concerned feedback processes can include different types of barriers that impede learning. Sterman (2000, 2001) has described several of such learning barriers. Also for instance Argyris (1999) and Senge (1990) have discussed various learning barriers. From the standpoint of innovation, we have selected some of the most essential learning barriers that affect the learning, the generative (double-loop) learning in particular. Some of the most important learning barriers are concerned with the (dynamic) complexity of the innovation process and innovation environment, the imperfect information and the deficient feedback from related decision making.

We will next discuss important learning barriers affecting the learning in innovation in organisations, and why these factors are significant in the context of learning in innovation.

4.1 Inherent complexity in innovation

According to Sterman (2000), the (dynamic) complexity related to natural and human systems like organisations is one of the major factors inhibiting the effective learning from the standpoint of organisations and individuals. Due to the inherent complexity in innovation, it is for instance difficult to determine high-leverage policies in managing and facilitating the innovation. Dynamic complexity arises from the interactions among the agents being part of a system in the course of time. Complexity includes the dynamics arising from various intertwined feedbacks and for instance the counterintuitivity of rational decision making. Some important factors contributing to the complexity in innovation are discussed next in this chapter.

- *Interaction between various agents and complexity.* The innovation is carried out all the more often in inter-organisational networks, not within one organisation. Compared to the coordination of activities within the boundaries of an individual organisation, coordinating activities, decision making and human-to-human interaction in inter-organisational relationships and networks is inherently more difficult due to the complexity induced by the large number of related and interdependent activities (e.g., Holmberg, 2000; Rigby et al., 2000). In a large number of studied companies, collaborative inter-organisational networking in innovation has been seen to significantly complicate the product development and to make it more difficult to control (Bruce et al., 1995).

- *Tight coupling of systems.* In an innovation process, there are a number of inter-organisational (networked companies that participate in the product development, customer organisations and end-users, research institutes and universities etc.) and intra-organisational (marketing, R&D, product development, sales, after sales) parties affecting and contributing to the innovation results with formal and informal feedback channels. These various tightly coupled parties affect each other in a plethora of complex, intertwined ways. The significance of cooperation is reflected in the studies that investigate the factors affecting the success and failure of innovation: the successful inter-organisational and intra-organisational cooperation is one of the most essential success factors in innovation (e.g., Read, 2000), and according to some studies, the most important detected success factor (Muffatto and Panizzolo, 1996).

If the communication and cooperation does not work properly between the various parties in the innovation-related networks, systemic self-reinforcing vicious loops can be created, which can still further lengthen the development time, decrease the quality of products and increasingly focus the operation on the short-term focus and fire-fighting mode. Such vicious loops are a result of the tight coupling of various innovation-related parties and the deficient communication and feedback structures between these parties. Without understanding the complex systemic structure of the interplay of the intertwined parties, the vicious loops can be very hard to be detected, improved or eliminated (Repenning, 2001; Kärkkäinen and Elfvengren, 2002; Akkermans et al., 1999).

One further factor increasing the complexity of innovation is that product innovation is often carried out in a multi-project environment with several simultaneous projects, which significantly increases the complexity, leading easily to self-reinforcing vicious loops and fire-fighting, i.e., the unplanned allocation of resources to fix problems discovered late in a product's development cycle (Repenning, 2001).

4.2   Incomplete, limited information

Time and cost constraints affect the quantity and quality of information in decision making. It is very costly and very difficult, practically impossible to gather enough information and knowledge to make fully rational, well-informed choices in such a complex area as product innovation. Quite often, companies face enormous challenges even in gathering all the existing, even quite relevant information located inside the innovating company (e.g., Holt, 1984). Therefore, the decision-making tends to be only limitedly rational in innovation.

The development cycles from product definition to market launch are generally very long in innovation activities, months or even years. Ideally, the factors affecting the commercial success should be anticipated until as far as the moment of market launch and during the whole life cycle of the products. However, it is not possible to know even all the most essential factors that affect the product success when the product is launched in advance, such as the market and customer needs.

4.3   Feedback from decisions

Some of the main factors affecting the feedback related to decision making concerning innovation deal with the long time delays from decisions to feedback, the long physical

distance from decisions to their effects and feedback, the difficulty to differentiate which decisions and other factors really caused a failure or a success in the innovation process or contributed to it in a longer term. Also the misperceptions of received feedback or lacking feedback are important factors. These are next discussed in more detail.

- *Time delays*. Due to the nature of innovation activities and the length of innovation cycles, the time delay can often be months or years, even ten years from decision to success or failure, or a clearly noticed effect in the innovation system – i.e., before the decision-related effects show properly in the form of product failures and unsatisfied customers. This, as well as the complexity of innovation from the standpoint of effective learning is probably reflected in the study of Schneiderman (1988), which shows that the time required to cut defects in half in complex organisational processes with long time delays such as product development had improvement half lives of several years or more.

- *Long physical distance.* The effects from innovation-related decisions do not normally show directly to the decision-maker, but they often appear in physically distant places, i.e., in other parts of the organisation, in other organisations of the same innovation/product development network, or in customer organisations. Feedback about the effects of a decision is not direct, and it also changes easily on the way to the decision-maker.

- *Missing feedback, misperceptions of feedback.* There are a number of barriers to learning in organisations which are connected for instance to the often compartmentalised way that organisations operate. Such barriers limit or bias the flow of information, as well as the feedback from other departments in the case of product innovation. This has a significant impact in the innovation process, limiting for instance the learning from the market and customer information and feedback (see e.g., Adams et al., 1998). In addition, due to the long time-horizon of innovation, as well as to the complexity of the innovation as a process, and the large number of actors both within and outside the innovating organisation that affect the success of innovation, it can be very hard to determine which decisions contributed positively or negatively to the results in the innovation process.

5   Systems thinking

Systems thinking is one of the skills needed for learning in an environment of constant change such as innovation and product development environments. To be able to combine information from different sources requires seeing the holistic view of the situation. Systems thinking also focuses attention to the relationships and dependencies of things through feedback loops which can be connected to other feedback loops (Ballé, 1994). Senge (1990) and Senge et al. (1994) sees systems thinking as the core discipline when building a learning organisation. The other four disciplines, which are personal mastery, mental models, shared vision and team learning are connected through the common systems thinking 'umbrella'.

Systems thinking can help in achieving generative learning, in order to be able to see the new possibilities and to question the present assumptions in the organisation. The barriers arising from complexity can be overcome with systems thinking since the whole situation and the interacting relationships can be seen more clearly.

Systems thinking has been discussed for many decades already and there are numerous researchers in the area. Senge et al. (1994) have had a profound impact on the theory combining systems thinking and learning. In a wide sense, systems thinking is a set of knowledge, tools and principles which helps to see wider connections and things influencing them in a holistic way. Behind all these tools is a belief that events and decisions follow a certain structure, a principle that has to be found. Systems thinking has become a powerful aid for changing patterns of action and functions in an organisation.

Senge et al. (1994) emphasises the importance of systems thinking because the organisations and the environment they operate in have become more complex. The methods of systems thinking have been designed to help to understand the dynamic reality and see the structures and models behind the real-world events. A general comparison of analytical thinking and systems thinking is presented in Table 1 below.

Table 1   Comparison of analytical and systems thinking

	Traditional analytical thinking	*Systems thinking*
Level of understanding reality	Seeing events and patterns	Seeing the structures behind the events and patterns
Type of learning	Single-loop, adaptive	Double-loop, generative
Mental models	Unchanged	Questioned and changed
Direction of analysis	Breaks the whole into parts	Combines the parts into a whole
Relationships	Direct causal relationships	Feedback loops, interaction of elements
Impact on innovation process	Focus on correction of errors, innovations within existing mental models	Helps to create new mental models and new basis for innovations

Source: Based on Senge (1990), Senge et al. (1994), Sterman (2000), Ballé (1994) and Aronson (1997)

One of the greatest challenges for learning in an organisation is to be able to interpret the events around it, to predict changes and to actively influence them to achieve competitive advantage. This means that on one hand, the changes in the environment are reflected on both the thinking and the actions in the organisation, and on the other hand, also the organisation has an effect on its environment. Understanding this interaction and the possibilities it presents requires systems thinking, in order to see things as a whole and to see the important areas which must be influenced in order to influence the system. In addition to the events, systems thinking helps to see the structures that influence them in the background.

According to Aronson (1997), systems thinking can provide some of its greatest benefits by directing innovation efforts so that they will not be compromised by the lack of appreciating the holistic picture of the situation. Targeted innovation efforts that take into account the whole big picture situation can lead to greater and longer lasting benefits for the organisation.

6 Discussion and further research

According to Senge (1990), a learning organisation continuously develops its skills to create its own future: people in the learning organisation create their own reality and can change it, and the learning process is about the ability to work in a new way and about internalising the things you have learned. Systems thinking, from the point of view of learning, means the ability of the individual to see the system around him from a new perspective.

Systems thinking can be useful in an organisation especially when the objective is to achieve completely new, radical innovations. Also it can help in describing complex situations like product development co-operation between companies, or just co-operation between departments of one company. Also, systems thinking helps to achieve generative, double-loop learning, which is more efficient in the long run than single-loop, adaptive learning. When the environment is changing fast and there is a need to learn fast, like typically in high-technology markets, generative learning and systems thinking are important.

One concrete way to bring systems thinking methods into practice is to use the Soft Systems Method (SSM) developed by Checkland (1981) to describe and analyse the complex interrelationships included in a product innovation system consisting of both inter- and intra-organisational networks. The method is normally used to support complex change processes in organisations, and it can be used to describe the current situation and the future vision in strategic decision-making situations. Another useful way to implement systems thinking in an organisation in the context of innovation process facilitation is to use a systems-based analysis approach from Allee (2003) to describe the network in which the organisation operates.

A more in-depth approach for understanding and analysing innovation in the field of systems thinking is the modelling approach (system dynamics) (see e.g., Sterman, 2000), which is well-suited for analysing the more detailed dynamics involved in complex processes like innovation.

These approaches are just examples of the various approaches and techniques based on systems thinking. Still, they are useful in providing concrete ways in proceeding with the implementation of systems thinking into the daily operations in organisations. However, the various approaches and techniques available for implementing systems thinking in organisations, and their ability to support the facilitation of the various barriers for effective learning in innovation will be evaluated in more detail in the further studies.

In this paper, a preliminary framework for categorising the barriers to learning and their implications in innovation process has been suggested, as well as some systems thinking methods that can be used to support generative learning. Further research is needed to complement the framework to include all related issues, and to find the suitable methods to improve systems thinking skills and learning in organisations. One possible topic for future research is also the applicability of different methods and the ease of their adaptation to innovation process.

The significance of the study comes from the assumption that since innovations are mainly based on the creation of new knowledge, systems thinking can support the complex process of innovation and help to understand how the process can be influenced. The capability for systems thinking is essential for instance for the understanding and effective improvement of the organisational operation and behaviour by recognising areas of high leverage.

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Learning in networks: an exploration from innovation perspective

Jukka Hallikas, Hannu Kärkkäinen and Hannele Lampela*

Lappeenranta University of Technology,
Department of Industrial Engineering and Management,
P.O. Box 20, FIN-53851 Lappeenranta, Finland
Fax: +358-5-621 2667   Email: Jukka.Hallikas@lut.fi
Email: Hannu.Karkkainen@lut.fi
Email: Hannele.Lampela@lut.fi
*Corresponding author

Abstract: Innovation and product development are by far the most knowledge intensive and complex processes in organisations, meaning that they are among the most challenging and critical processes from the standpoint of new knowledge creation and effective learning. The firms' learning capabilities play a crucial role in generating innovations. By networking, companies are able to create and share new knowledge efficiently and the importance of networks in successful innovation management has increased significantly during the last few years. The aim here is to study the literature on learning, innovation and networks, particularly learning in inter-organisational networks. We evaluate and discuss important approaches to learning found in the literature from the standpoint of innovation management and networks. Since innovation is a particularly challenging and important task or process from the standpoint of knowledge creation and learning, several viewpoints to learning should be recognised and used simultaneously when aiming at effective learning.

Keywords: innovation networks; inter-organisational learning; knowledge management.

Biographical notes: Jukka Hallikas is Project Manager and Senior Researcher at the Technology Business Research Center at Lappeenranta University of Technology, Finland. He received his DSc (Tech) from the Lappeenranta University of Technology. His research interest focuses on the management of value networks, risk management in supply networks and learning in inter-firm relationships. He has published several scientific articles, books and book chapters on inter-firm relationships and networking.

Hannu Kärkkäinen is Professor at the Department of Industrial Engineering and Management at Lappeenranta University of Technology in Finland. He received his DSc (Tech) from the Lappeenranta University of Technology. His current research interests include the early-phase management of R&D, knowledge management and decision-making in innovation, customer needs assessment in business-to-business organisations and the co-operation and value networks in

product innovation. He has published a number of refereed international journal articles, as well as books, book chapters and other publications on the above research topics.

Hannele Lampela holds MSc (Econ.) and MSc (Tech.) degrees from Lappeenranta University of Technology, Finland. She has previous work experience from software companies in various sales and marketing positions and at the moment she works as an assistant and a PhD student at the Department of Industrial Engineering and Management at Lappeenranta University of Technology, with diverse courses on knowledge management and innovation.

1   Introduction

By networking, companies are able to create and share new knowledge efficiently and the importance of networks in successful innovation management has increased significantly during the last few years. The information gathering and sharing activities, as well as knowledge creation within innovation networks, have a crucial importance since they help the organisations to learn about and from each other. The firms' learning capabilities play a crucial role in generating innovations (Sinkula et al., 1997). Learning enables the organisations, for example, to renew themselves and to keep up with competition and furthermore, learning faster and more effectively than the competitors may be the only source of sustainable competitive advantage in competitive markets (e.g. Slater and Narver, 1995). Furthermore, as the creation and utilisation of knowledge has become the key to sustainable competitive advantage, the opportunity to learn from partners provides strategic advantages for companies (Inkpen, 1998). It follows that the knowledge acquisition through learning is an inherent objective of networking and collaborative innovation. Still, learning in networks has not been studied very exhaustively and the extant literature is rather scattered and ambiguous. We have found few studies concentrating specifically on learning in innovation networks.

As the amount of actors in a network grows and the changes in the environment become faster, the complexity of the innovation process increases significantly. This, in turn, increases the need for effective learning. For example, in high technology companies such as the ICT and the software industries which have been described as highly information intensive and where changes in the operating environment are fast, the ability to learn effectively in a network can be crucially important for their competitiveness. For example the study of Powell et al. (1996) from the biotechnology industry reveals that the locus of innovation is in networks of learning, rather than in individual firms.

However, there are also threats involved in the inter-organisational learning and learning in networks which should be carefully taken into consideration when planning partnerships and networks with a focus on inter-organisational learning. One widely cited downside of alliances and networks, concerning organisational learning in particular, is that networking and alliances may lead to the spill-over of a firm's strategic assets to other organisations, as well as to the appropriation of competences and capabilities by their partners (e.g. Jarillo and Stevenson, 1991). Networks and alliances also create dependency relationships, this leading potentially to the narrowing down of expertise and to limitations on creativity and competitiveness (Beeby and Booth, 2000). According to Kekäle and

Viitala (2003), while the learning aim can produce a competitive edge for organisations, it can also create tensions within the network: through learning, a partner can become a competitor. Furthermore, according to Andersen and Christensen (2000), as learning includes breaking up some of the old routines and the introduction of new ones, learning always involves the elements and phases of uncertainty and volatility. This means that constant learning may be equal to non-stability, where any rationalisation of economic performance is difficult or even impossible.

There are numerous views on learning that are in many ways interdependent and also partly overlapping. For example, in psychological or pedagogical literature the topics related to learning have been studied for a long time already and, recently, organisational learning also has been a topic of fast-growing interest in different fields of managerial literature such as strategic management and innovation.

The perspectives on learning that have been selected for this study are Nonaka and Takeuchi's knowledge conversion processes, organisational memory, systems thinking, dynamic capabilities view, absorptive capacity and exploitative and explorative learning. There are also many other views on learning that have gained much interest in recent years, for example the communities of practice perspective or using blogs and other technology-mediated tools for learning. Despite their apparent significance, many of them seem to be less fundamental in a sense that their usefulness in learning can be evaluated, at least partly, utilising the theories and perspectives described in this study. Others have been left out of the scope of this study because they have not been referred to as significant, specifically in the context of innovations or networks and they have been academically and empirically less researched. Specific models related to organisational learning (such as the 4I model from Crossan et al., 1999) also have been left outside the scope of this study.

The selected perspectives or views have been referred to by many different authors and have gained attention in the areas of innovation and networks. They can be regarded as currently important or rising theories or viewpoints on learning, they all have a significant amount of empirical research behind them that has proved them to be valid in the scientific perspective, they can be considered to be rather fundamental and general perspectives that lie behind many other learning perspectives and they have been published in various important academic journals. We are also deliberately including in this study different types of views to highlight the differences that they have and to have possible implications from a broad spectrum of views.

The study combines three areas that have not yet been studied together very thoroughly:

- learning
- networks
- innovation.

There is a substantial amount of articles or other writings on any two of these areas combined but we have been able to find very little literature on the combination of all three topics. In this paper we try to find implications especially to this joint area covered by all three perspectives. The importance of combining these areas of interest is growing since learning is seen as an integral part of innovation and innovations are produced increasingly in inter-organisational networks.

The main research question in this study is which theories, approaches and views on learning, according to the literature, appear to be useful and essential in the context of learning in inter-organisational relationships and networks, especially in innovation networks? Secondly, what kind of challenges or barriers for learning exist when considering learning in innovation networks? Thirdly, what kind of implications do each of the presented views provide for inter-organisational learning?

The research is conducted by studying different views on learning from literature and finding the issues that each view emphasises for efficient learning and especially considering networks. We have also studied challenges that prohibit efficient learning that need to be considered in networked innovation and some suggestions are given as to how these might affect innovation. The implications from different viewpoints are discussed at the end of the paper. The combining of different views, gives a wide range of issues to be considered for networked innovation. The emphasis of this work is especially on learning, although networks will be discussed as an environment for innovations.

2   Views on organisational and inter-organisational learning

There are rather diverse views on the topic of when an organisation learns. According to de Weerd-Nederhof et al. (2002), among many other studies with similar types of views, there are two main typologies of learning processes: one sees learning as single or double loop (or deutero) learning, the other emphasises the cognitive or behavioural dimensions of learning.

One rather common perspective in literature is that organisations learn when their knowledge in the form of *rules and standard operating procedures* is changed (Argyris and Schön, 1996; see also Holmqvist, 1999), i.e. their *actual* behaviour changes. This corresponds to the behavioural view on learning. From another perspective, the information processing perspective, an organisation or another entity learns "if, through its processing of information, the range of its *potential* behaviours is changed" (e.g. Huber, 1991). Drawing from this, Sinkula (1994) does not view overt change as a necessary condition for learning to have occurred, nor does he view actual decision making as a necessary condition for learning. This latter view corresponds to the cognitive aspect of learning. In the tradition of organisational cognition perspective, an important tenet is that organisational learning is more closely related to sense making (Sackmann, 1991; Sinkula, 1994) than it is to decision making.

An important feature in the analysis of learning focuses on the distinction of learning between single- and double-loop learning. The basic premise here is that organisations learn and make decisions and adjustments often through the mechanism of feedback (Argyris and Schön, 1996). Argyris (1999) states that whenever an error is detected or corrected without questioning or altering the values of the system, it is defined as single-loop learning. Double-loop learning occurs when the mismatch in the system is corrected by first examining and altering the governing variables of the system, designating changes in organisational processes and structures. According to Argyris (1999) both types of learning are needed in organisations. He concludes that, where single-loop learning is mostly addressed to the simple and operative actions, double-loop activities are related to the complex and strategic organisational processes, which many times control the effectiveness of the system.

2.1 Theories and viewpoints related to organisational learning

It can be stated that, basically, organisations learn in two ways: through their own experiences or through the experiences of other organisations (Levitt and March, 1988; see also Håkansson et al., 1999). Learning from one's own experiences includes experimenting and interpreting the earlier outcomes, while learning from others means the transfer of knowledge embedded in products or processes, or transferring the knowledge in a more pure form.

According to Levinthal and March (1993), organisational learning should aim to cope with the problem of balancing the competing goals of exploration, i.e. the development of new knowledge and exploitation, i.e. exploiting current information, knowledge and organisational competencies instead of the strong tendency in companies to excessively emphasise either of the two. Senge (1990) defines the learning organisation as an organisation that is continually expanding its capacity to create its future. The capability to innovate and being innovative, as well as learning from the future can, therefore, be seen as a fundamental element of learning organisation. Further, in the core of learning organisation is the ability to see the big picture of the problem, i.e. the large systemic picture of the organisation and its environment, as well as their complex interrelationships. This will require both seeing the problems caused by something else and seeing how our own action creates the problem we experience.

According to Nooteboom (2004), the content of learning in organisations may vary from joint production, problem solving and the development of new practices to sharing of knowledge and organisational change. The purpose of the learning process may be the sharing and producing of the knowledge for organisational purposes. Much of this knowledge is embedded in the different organisational routines and procedures. As argued by Argyris and Schön (1996), the foundation of effective management is to be able to transform organisational objectives into routines. Further, these routines should be developed and used effectively to balance the exploitation and exploration of resources in the organisation (March, 1991). Efficient exploitation of current resources is needed in the short-term and exploration of new resources is needed to survive in the long-term (Nooteboom, 2004).

The practices of learning can embrace different units of analysis. A lot of conducted research emphasises the intraorganisational unit of analysis. In this paper we focus on inter-firm structures and processes of learning. Our premise is that inter-organisational learning and learning processes have an important role in the management of innovation in inter-organisational relationships.

2.2 Networks and learning

The importance of inter-organisational collaboration has increased remarkably since companies have concentrated on their core competencies and relied more on the external resources and knowledge of business partners. Motives for networking and collaboration are related to the economies of scale and scope, sharing of knowledge, risk transfer and the production of new innovations (see Bruce et al., 1995). Many of these motives require effective inter-organisational learning to take place. As pointed out by Doz and Hamel (1998), learning is a key element determining the success or failure of co-operation. They also state that the partners' capability to learn over time is an important part of the collaborative planning process.

The learning of individuals and individual organisations of the network can be seen as one important component of inter-organisational learning. However, inter-organisational learning is different from the learning of individual organisations in the sense that, not only the individual organisations or other individual parts of the network learn but also the organisational network itself learns as a whole and is able to store knowledge and information in various ways, for instance as inter-organisational processes (see e.g. Moorman and Miner, 1997; Walsh and Ungson, 1991). On the other hand, Larsson et al. (1998), for example, describe the inter-organisational learning as distinct from organisational learning by emphasising the significance of learning synergy or the interaction effect between the organisations which would not have occurred if there had not been any interaction.

The above means, effectively, that an inter-organisational network can possess significantly more knowledge and information than is the total sum of the knowledge and information possessed by the individual parts of the network separately (see Figure 1 below). An inter-organisational network can also benefit from the learning synergy by learning faster than would be possible without the synergistic effect. These issues can be seen as important objectives of effective inter-organisational learning, making it distinct from organisation-level learning.

Figure 1   Illustration of the aim in inter-organisational learning

$$K_{NW} > K_1 + K_2 + \ldots + K_n$$

Where
    K_{NW} is the knowledge base of the inter-organisational network as a whole.
    K_1 through to K_n are the separate knowledge bases of individual network participants from
    Organisation 1 through to Organisation n.

Furthermore, another important aim of effective inter-organisational learning is to enable the network to learn and adopt new knowledge faster and more efficiently than the individual participants could as separate organisations. On the other hand, effective learning may provide access to the knowledge over competitors with a weaker learning capability. The above abilities can be an important source of sustainable competitive advantage, especially in situations where the external market conditions change rapidly. Consequently, synergy can be seen as an important fundamental component in inter-organisational learning. Our presumption, based on the studied literature concerning inter-organisational leaning is that, if effective learning is aimed at inter-organisational networks and learning is carefully observed and supported from various different viewpoints, such viewpoints described later in this study, the knowledgebase as well as the ability of a network to learn and adopt new knowledge *as a whole* can be significantly greater than the sum total of individual network participants' observed separately.

The dynamic capabilities approach has developed from the resource-based view (Barney, 1991) emphasising the renewal of the resources available for the company. The basic assumption of the resource-based view is that the resources companies own should complement each other and the integration of resources, particularly knowledge resources, is the key to learning and development. The ability to achieve new forms of competitive advantage to match the changing business environment is called 'the dynamic capabilities'

and in this view, learning is seen as one of the most important organisational processes (Teece et al., 1997). Learning is a dynamic social process and the organisational knowledge created is stored in routines or new patterns of activity. In networks, partnerships can enable new learning by identifying routines that need to be modified or renewed.

According to the theories of organisational memory derived from cognitive theories, organisations are assumed to create, use and store information and knowledge in a similar way to individuals (e.g. Moorman and Miner, 1997; Walsh and Ungson, 1991). Organisational memory consists of individually held memories and routines in an organisation. These routines can be technical, social or business ones. Business and social routines become more important as the complexity of the business setting or commonly developed products increases (Koistinen, 2003).

An essential element in learning is related to the concept of absorptive capacity. According to Cohen and Levinthal (1990), absorptive capacity refers to the organisations' capability to utilise the external knowledge needed in the performance. Nooteboom (2004) defines that absorptive capacity is the ability to understand others at different levels of cognitive distance. The extension for the absorptive capacity theory is provided by Dyer and Singh (1998) who have introduced the concept of 'partner-specific absorptive capacity' to define the capability to identify and adopt useful knowledge from the specific partner.

There are several challenges related to effective learning in inter-organisational relationships. One, which derives from the organisational theory, is the balance between exploitation and exploration in networks. According to Nooteboom (2004), in networks of exploration the future uncertainty of structural change is taken into account which cannot be driven by the static efficiency of exploitation. This requires the innovation of new business concepts, products and services. In exploration, the dense ties and optimal cognitive distance of partners is needed in order to produce novel solutions. Respectively, in networks for exploitation the development of existing assets and competencies is crucial.

3 Challenges for inter-organisational learning in innovation

The significance of effective learning and knowledge creation in innovation is continuously growing, since the development times and life-cycles of innovations are shortening and the competition is becoming tougher and more global. These factors also make the organisational learning an increasingly more challenging and important task since more information needs to be recognised, gathered, disseminated and utilised in a shorter available time.

We will discuss next the important learning barriers affecting innovation-related learning in organisations. We explore also why these factors are significant in the context of learning in innovation.

Eppler et al. (1999) evaluate and classify organisations' various business processes from the knowledge perspective according to their knowledge intensity and process complexity, demonstrating that knowledge-intensive processes can be distinguished from other business processes through a series of attributes and inherent problems. According to them, innovation and product development are by far among the most knowledge intensive and complex processes in organisations. This means that they are among the most challenging and critical processes from the standpoint of new knowledge creation and effective learning. Therefore, the issue of learning should be highly emphasised in

the case of innovation and product development at the individual, organisational as well as the inter-organisational level. Knowledge intensive processes generally need a long learning time before they can be mastered. A further challenge from the standpoint of learning is that the knowledge and information related to innovations, such as market and customer information, becomes outdated relatively quickly compared with other organisational information. This means, for instance, that the capabilities of 'unlearning' and the questioning of present knowledge, as well as the concept of double-loop learning are important and particularly relevant in innovation-related learning.

From the standpoint of knowledge creation and learning, the innovation and product development activities and processes are particularly challenging, for instance, because they include a relatively large number of agents and process steps interacting with each other leading, for example, to increased coordination complexity, tight interdependencies between various agents and process steps, long development cycles before the results of decisions and actions can be observed and feedback can be received, long physical distance from actions to their effects and missing or misperceived feedback from decisions and actions (see e.g. Eppler et al., 1999; Holmberg, 2000; Rigby et al., 2000). Development processes in innovation also are quite complex and often include a vast amount of contingencies.

Systems thinking emphasises the importance of feedback for effective learning and Sterman (2001) even says that all learning is based on feedback. Double-loop learning is seen as more effective than single-loop learning, since it also changes the system itself (Argyris, 1977). A holistic, systemic picture is needed of the whole company to enable the managers to find the areas where the greatest impact can be reached. Senge (1990) talks about seeing the structure behind the system and the importance of recognising the repeating patterns in the behaviour of the system. In a network striving to learn more effectively this means that, to enable continuous feedback, the co-operation link between the organisations must be strong and kept active.

All the parties in the network also should have an understanding of the larger system of which they are a part and it is important to define the interactions within and outside the network. The larger system refers to the direct and indirect network relationships, as well as to a company's industry.

In the following, some of the most essential factors affecting the learning are described which are connected to the inter-organisational learning, the emphasis being on factors (see Sterman, 2000) that affect particularly the effective generative, double-loop form of learning. Some of the main factors affecting the feedback related to decision-making concerning innovation deal with the long time delays from decisions to feedback, the long physical distance from decisions to their effects and feedback and the difficulty to differentiate between which decisions and other factors really caused a failure or a success in the innovation process or contributed to it in a longer term. The misperceptions of received feedback or lacking feedback also are important factors.

3.1   Interaction between a number of actors and activities

The innovation is carried out all the more often in inter-organisational networks, not within one organisation. Compared with the coordination of activities within the boundaries of an individual organisation, coordinating activities, decision making and human-to-human interaction in inter-organisational relationships and networks is inherently

more difficult due to the complexity induced by the large number of related and interdependent activities (e.g. Holmberg, 2000; Rigby et al., 2000). In a large number of studied companies, collaborative inter-organisational networking in innovation has been seen to significantly complicate the product development and to make it more difficult to control (Bruce et al., 1995).

3.2 Tight inter-connectedness of actors

In an innovation process, there are a number of inter-organisational (networked companies that participate in the product development, customer organisations and end-users, research institutes and universities etc.) and intra-organisational (marketing, R&D, product development, sales, after sales) parties affecting and contributing to the innovation results with formal and informal feedback channels. These various tightly coupled parties affect each other in a plethora of complex, intertwined ways. The significance of cooperation is reflected in the studies that investigate the factors affecting the success and failure of innovation: the successful inter-organisational and intra-organisational cooperation is one of the most essential success factors in innovation (e.g. Read, 2000) and, according to some studies, the most important detected success factor (Muffatto and Panizzolo, 1996).

3.3 Time delays

Due to the nature of innovation activities and the length of innovation cycles, the time delay can often be months or years, even ten years from decision to success or failure or a clearly noticed effect in the innovation system – i.e. before the decision-related effects show properly in the form of product failures and unsatisfied customers. This, as well as the complexity of innovation from the standpoint of effective learning is probably reflected in the study of Schneiderman (1988), which shows that the time required to cut defects in half in complex organisational processes with long time delays such as product development had improvement half lives of several years or more.

3.4 Long physical distance

The effects from innovation-related decisions do not normally show directly to the decision maker but they often appear in physically distant places, i.e. in other parts of the organisation, in other organisations of the same innovation/product development network or in customer organisations. Feedback about the effects of a decision is not direct and, also, it changes easily on the way to the decision maker.

3.5 Missing feedback, misperceptions of feedback

There are a number of barriers to learning in organisations which are connected, for instance, to the often compartmentalised way that organisations operate. Such barriers limit or bias the flow of information, as well as the feedback from other departments in the case of product innovation. This has a significant impact on the innovation process limiting, for instance, the learning from the market and customer information and feedback (see e.g. Adams et al., 1998). In addition, due to the long time-horizon of innovation, as well as to the complexity of the innovation as a process and the large

number of actors both within and outside the innovating organisation that affect the success of innovation, it can be very hard to determine which decisions contributed positively or negatively to the results in the innovation process.

4   Viewpoints on inter-organisational learning in innovation

We have selected six divergent approaches to represent theories and methods relevant to the topic. The selected approaches are: conversion of explicit and tacit knowledge, organisational memory, systems thinking, dynamic capabilities, absorptive capacity and learning for exploitation and exploration.

Based on our extensive literature review of several relevant sources, as well as our review and analysis, all of the selected approaches and views seem to be relevant and useful for learning and are often highlighted in the literature related to organisational learning or, specifically, learning in networks. These represent the common views presented on learning when focusing on learning, innovation and networks.

Some of these approaches, particularly dynamic capabilities and systems thinking, are not directly linked to learning or the theories of learning in particular. However, these approaches and the found related literature provide quite important and useful insights for effective learning in the context of inter-organisational networks. In relation to each other, each of the above approaches provides a complementary perspective on inter-organisational learning and innovation.

Table 1 opposite summarises the main findings of the found literature on inter-organisational learning and innovation. In Table 1, the main points of each approach are illustrated in terms of their emphasis on effective learning, implications for inter-firm learning and implications for networked innovation. In the left column, descriptive names are presented for the selected theories and viewpoints, as well as some important authors. In the next column some key factors are listed, which are emphasised as important for effective learning in the literature concerning each of the selected approaches. The two right-hand side columns discuss the implications that these factors have, the first for effective learning between organisations in general and the second specifically for innovation-related learning in networks.

5   Discussion and conclusions

Organisations' ability to learn faster and better has become an essential element of competitive advantage. The increasing interconnectedness and complexity of the business environment requires effective learning, both within and between organisations. In the pursuit of a competitive advantage, learning in the context of innovation and innovation related networks is a very challenging but increasingly more important task for companies. Effort put into the development of inter-organisational networks that support effective learning in innovation can provide as much as a basis for a relatively sustained competitive advantage for companies.

Table 1 Selected perspectives on learning and their implications for effective learning, inter-firm learning, and learning in networked innovation

Theory/ perspective (Authors)	Following factors emphasised in effective learning	Implications for inter-firm learning	Implications for networked innovation from the standpoint of effective learning
Conversion of explicit and tacit knowledge (Nonaka and Takeuchi, 1995; Holmqvist, 1999)	Key to knowledge creation is in the mobilisation of organisational tacit knowledge and in the conversion of different knowledge types, the tacit and explicit (i.e. knowledge creation processes).	• Knowledge creation processes are needed also between organisations. Holmqvist (1999) explored eight conversion processes in inter-organisational knowledge creation in particular, in the context of case Scandinavian PC Systems.	• The different knowledge creation processes should be built-in explicitly and properly in inter-organisational innovation-related cooperation as well as in formal/informal innovation processes.
Exploitative and explorative learning (March, 1991, Nooteboom, 2004)	Organisational learning occurs primarily via organisational routines (i.e. actions, procedures, norms and models). These can be divided according to their purpose for improving the existing operations of the system (exploitation) and for the purpose of increasing the capacity to create (exploration) and should be properly balanced.	• Both routines for exploitation and exploration are needed in order to assure the continuity of the life-cycle of inter-organisational relationships. • The proper balance between exploitation and exploration is important and it varies in the different stages of the network relationship.	• The importance of routines for exploration increases as a source of innovation, renewal and competitive advantage. • These routines are aligned with future planning and renewal of the network relationship.
Absorptive capacity, relative absorptive capacity Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Dyer and Singh, 1998)	Previous knowledge enhances the learning of similar knowledge. Learning is most effective when the new knowledge to be assimilated is related to the existing knowledge.	• Student firms have the greatest potential to learn from teachers with similar basic knowledge but different specialised knowledge. • Inter-organisational routines can be made more effective by enhancing partner-specific absorptive capacity (ability to absorb knowledge from specific partner).	• An important question is how the student firm should select its teacher and which criteria should be used. • Innovation partners should possess similar types of knowledge bases, similar organisational structures and compensation policies, similar knowledge-processing style, as well as similarity in the companies' commercial objectives (the dominant logics) to ensure effective inter-organisational learning.

Table 1   Selected perspectives on learning and their implications for effective learning, inter-firm learning, and learning in networked innovation (continued)

Theory/ perspective (Authors)	Following factors emphasised in effective learning	Implications for inter-firm learning	Implications for networked innovation from the standpoint of effective learning
Organizational memory (Walsh and Ungson, 1991; Moorman and Miner, 1997; Koistinen, 2003)	Organisations are assumed to create, use and store information and knowledge in a similar way to individuals. Learning occurs via doing and experiencing and is stored in organisational work and core processes, as well as e.g. products and services.	• Significant effort should be focused on the creation of inter-organisational routines and work processes and e.g. the creation of formal and informal networks between the co-operating companies. • Also more static forms of memory such as databases etc should be developed between organisations.	• Companies should focus their effort on the creation of common, commonly understood innovation processes and routines, as well as the creation of other important memory forms; not only technical and more static forms of memory like databases.
Systems thinking (Senge, 1990; Sterman, 2000, 2001, Argyris, 1977, 1999)	Interactions and interdependencies are an important focus of interest in learning. Feedback is an essential prerequisite for effective learning. It is important to recognise the whole structure of an organisational system. Identification of virtuous and vicious loops. Capability of systems thinking enhances the capability for double-loop learning.	• All the parties in a network should have a common and in-depth understanding of their mutual interdependencies and the larger system of which they are a part. • Continuous, regular feedback and approaches that support the utilisation of feedback are important.	• Systems thinking ability can help to recognise the patterns and structures of complex innovation processes in networks. • It enables questioning the existing mental models as well as creating radical innovations (e.g. McKee, 1992). • Identifying the virtuous or vicious loops in innovation processes caused e.g. by network structures and taking advantage of the loops in questioning the present thinking as well as in creating new ways to innovate.
Dynamic capabilities (Teece et al., 1997, Dyer and Singh, 1998)	Based on the idea of complementary assets and continuous ability to renew and adapt competencies through learning.	• Firm's critical resources may extend beyond firm boundaries (Dyer and Singh, 1998). Partnerships enable inter-firm learning by helping to recognise dysfunctional routines and develop them.	• Identification of critical resources in innovation process. • Strategic integration of complementary capabilities in innovation networks leads to better chances for radical innovations.

In the literature, there are diverse views on the concepts of learning and organisational learning. There seems to be a multitude of research on learning and organisational learning. The combinations of learning and innovation, learning in inter-organisational networks and innovation networks also have been explored. Usually, however, merely one or a couple of standpoints have been exploited in these studies, providing a one-sided and often quite inadequate view on effective learning. Further, we have found very few articles on the subject of learning in inter-organisational networks. Instead of exploiting just one standpoint on the topic, we have studied this subject from the standpoint of rather diverse views and theories. These can effectively support learning in networks both through changes in the actual behaviour in the form of for example, rules and standard operating procedures, as well as by affecting and enlarging the range of potential behaviour of networks and making the networks more agile and responsive to changes in the business environment.

Since innovation is a particularly challenging and important task or process from the standpoint of knowledge creation and innovation, several standpoints should be recognised and used when aiming for effective learning. Attention should be focused on the effective facilitation of learning, particularly in information and knowledge intensive industries, the competitiveness and future of which depend on their ability to learn and to renew themselves.

It seems that the various studied standpoints are relatively context-independent, in the sense that they can be used in different situations and are not restricted to any special circumstances but need to be considered simultaneously. However, for the efficient implementation of these views and to achieve more efficient learning, it might be that some views are more suitable in certain organisational situations than others.

On the basis of our study, we cannot at this stage directly recommend any single approach to be used exclusively in certain types of situations, industries or other contexts in innovation. Each studied approach covers some important aspects of learning and the different views and theories emphasise rather different types of approach that should be drawn attention to and focused on when organisations and networks aim to develop their learning abilities in innovation. No single standpoint or approach alone can provide a basis for effective learning. Effective learning with sustainable, long-term impact on organisational competitive advantage can be achieved most likely when various aspects and standpoints of learning are simultaneously taken into consideration when planning inter-organisational network cooperation.

In this paper, we have provided diverse insights and ideas for building learning into inter-organisational innovation processes. In our further research, we will operationalise the various aspects of learning and use them to enhance learning in different industries and case companies. We will also analyse more closely the context-dependency or independency of the studied learning views and approaches, leading to a more rational choice of suitable individual learning approaches or the combination of learning approaches in organisational networks from the managerial standpoint. In addition, we aim to identify learning practices that enable more effective inter-organisational learning and learning in networks particularly on the level of effective double-loop learning. These results will be reported and evaluated in later studies.

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Views and practices on inter-organisational learning in innovation networks

Hannele Lampela*

Department of Industrial Management,
Lappeenranta University of Technology,
P.O. Box 20, 53851 Lappeenranta, Finland
Fax: 358-5-621 2667
E-mail: hannele.lampela@lut.fi
*Corresponding author

Hannu Kärkkäinen

Department of Business Information Management and Logistics,
Tampere University of Technology,
P.O. Box 541, 33101 Tampere, Finland
E-mail: hannu.karkkainen@tut.fi

Abstract: In this paper, the aim is to study inter-organisational learning in innovation networks. In the context of organisational and particularly inter-organisational learning, due to, for instance, organisational and physical distances, various ICT tools and e-learning methods are of particular importance. The emphasis is on different currently important or increasingly important approaches and views on organisational learning that are relevant from the standpoint of networked innovation. Different learning approaches are analysed and their suitability in various situations and conditions of innovation networks is evaluated. Some useful practices to be considered in each learning approach are suggested.

Biographical notes: Hannele Lampela is an Assistant and a Doctoral student at the Department of Industrial Management at Lappeenranta University of Technology in Finland. She holds a MSc in Economics and in Technology, and works with diverse courses on knowledge management and innovation. Her research interests include innovation networks and inter-organisational learning.

Hannu Kärkkäinen is Professor at the Department of Business Information Management and Logistics at Tampere University of Technology in Finland. His current research interests include the early-phase management of R&D, knowledge management and decision-making in innovation, customer needs assessment in business-to-business organisations, and the cooperation and value networks in product innovation. He has published a number of refereed international journal papers in journals like *International Journal of*

Technology Management, *R&D Management* and *International Journal of Production Economics*, as well as books and other publications on the above research topics.

1 Introduction

In recent years, effective learning and knowledge generation have been acknowledged to have an important role in successful innovations and innovative processes in organisations (e.g., Soo et al., 2002; Moorman and Miner, 1997; Sinkula et al., 1997; Nonaka and Takeuchi, 1995; Koistinen, 2003).

As the research and development activities of organisations are increasingly organised in networks of several participants from outside the organisation, innovations in product or service development are born especially in the boundaries that combine different areas of expertise and operations (Lubatkin et al., 2001; Powell et al., 1996). These networks typically consist of parts of several separate organisations working together, but in distributed locations. They need to be in constant contact with each other to be able to coordinate the innovation activities.

Innovation networks and the effect of cooperation on the speed and spread of innovations especially in the case of technological innovations have been discussed for example by Rycroft (2007). Interfirm innovation networks are commonly seen as possessing both possibilities and weaknesses and they have been in the focus of growing interest for example from the point of view of co-evolutionary development (e.g., Gilsing, 2005). Learning in innovation networks has been operationalised in earlier research for example by simulations (Gilbert et al., 2007).

This form of organising in networks is challenging for the participants on both organisational and individual level for many reasons, particularly from the point of view of knowledge creation and sharing. Also, the organisation's learning capabilities have crucial importance in generating innovations (Sinkula et al., 1997). Learning enables the organisations to renew themselves and to keep up with competition. Furthermore, learning faster and more effectively than the competitors may be the only source of sustainable competitive advantage in competitive markets (Slater and Narver, 1995).

As the number of actors in a network grows and the changes in the environment become faster, the complexity of the innovation process increases significantly. This, in turn, increases the need for effective learning. For example, in industries that are considered as highly information intensive and where changes in the operating environment are fast, the ability to learn effectively in a network can be very important.

There has been discussion on whether networks of organisations are actually able to learn or not, in which sense they are able to learn and which various forms the learning may take in the network context, as well as where the accumulated learning can be stored within the organisational network (e.g., Nooteboom, 2004; Kekäle and Viitala, 2003; Holmqvist, 1999).

Our premise, which is generally speaking well grounded in the earlier organisational learning literature, is that in addition to an individual level of learning, organisational-level learning does exist and that there are synergies that enable organisational learning to be more than the sum of the learning of the individuals in the

organisation. The organisation can also possess other similar qualities, such as organisational memory, which is not the same as the memories and knowledge of its members, but something more that has developed over time (see e.g., Wexler, 2002; Moorman and Miner, 1997; Koistinen, 2003).

The theories of organisational learning are in this study extended to discussing organisational learning in a wider setting, between several organisations and organisational networks or partnerships. The aim is to study inter-organisational learning in innovation networks. We concentrate on different currently important or increasingly important approaches and views on organisational learning that are relevant from the standpoint of networked innovation. The approaches can also be considered to be fundamental and general perspectives that lie behind many other learning perspectives. We analyse the different learning approaches and evaluate their suitability in various situations and conditions of innovation networks.

First, to give an overview of learning in networks, we present several fundamental learning types, based on the division between behavioural and cognitive learning. In the next section, the selected approaches of organisational learning from the network perspective are introduced and evaluated according to their emphasis on the behavioural and cognitive components of learning, as well as with respect to their similarities and differences. The suitability of each theoretical approach for various situations or conditions in inter-organisational innovation networks is discussed, and some preliminary ideas on practices to support effective learning in innovation networks are proposed.

The results of the study contribute both to the academic community and practical innovation management, since the subject has not been studied very exhaustively and the present literature is rather scattered and ambiguous, despite the recent growing interest in organisational learning and innovation processes.

2   Types of organisational learning

Organisational learning and various organisational learning approaches can be thought to consist of and be based on some basic or fundamental concepts and types of learning. These concepts are briefly introduced in this section.

2.1   *Behavioural and cognitive learning*

In pedagogical literature concerning mainly learning on an individual level, learning theories have traditionally been divided into two different categories, depending on how learning is seen to take place. According to the behaviourist view, learning requires an observable change in behaviour. In the cognitivist view, however, an explicit change in behaviour is not necessary for learning to have occurred. The cognitivists state that a change on the cognitive level, potentially leading to a change in behaviour, is enough for learning to have occurred. The change in behaviour can also be a result of processes other than learning, i.e., mere adaptation to the situation without any lasting impact. The corresponding theoretical views are called behavioural theories of learning and cognitive theories of learning.

On organisational level, there are also rather diverse views on the topic of when an organisation learns. One rather common conception in the literature is that organisations learn when their knowledge in the form of rules and standard operating procedures

change (Argyris and Schön, 1996, see also Holmqvist, 1999), i.e., their actual behaviour changes. From another perspective, the information processing perspective, an organisation or another entity learns "if, through its processing of information, the range of its potential behaviours is changed" (Huber, 1991). Drawing from this, Sinkula (1994) views neither overt change as a necessary condition for learning to have occurred, nor actual decision-making as a necessary condition for learning.

2.2 Single loop and double-loop learning

Several models on organisational learning have been presented in the literature (Argyris and Schön, 1978; Senge, 1990; Nonaka and Takeuchi, 1995; Crossan, 1991). One of the best known has been developed by Argyris and Schön (1978). This basic model of organisational learning describes two levels of learning, the single loop and the double loop level. The basic premise here is that organisations learn and make decisions and adjustments through the mechanism of feedback (Argyris and Schön, 1996). Argyris (1999) states that whenever an error is detected or corrected without questioning or altering the values of the system, it is defined as single-loop learning. Double-loop learning occurs when a mismatch in the system is corrected by examining and altering the governing variables of the system, designating changes in organisational processes and structures, while according to McKee (1992), double-loop learning is based on questioning the existing structures, norms and values and requires radical changes. According to Argyris (1999), both types of learning are needed in organisations. He concludes that where single-loop learning is mostly addressed to simple and operative actions, double-loop activities are related to complex and strategic organisational processes, which often control the effectiveness of the system.

The type of learning needs to be considered in innovation context, as different kinds of objectives in the development work lead to different kinds of requirements for learning. The needed type of learning always depends on the situation, as new and radical innovations are possible with double-loop learning, which challenges the mental models of the actors, but sometimes, single-loop learning might be enough. Thus, the optimal level of learning has to be defined for each situation to learn effectively.

It is important that an organisation is able to utilise both types of learning and define the appropriate level of learning, according to the situation. It can be said that in creating innovations, single loop, corrective learning is sufficient for incremental improvements, but to achieve radical innovations, the organisation must also have the ability for double-loop learning (McKee, 1992). Adjusting this idea to include a partner relationship or to larger networks of several participants means that the network as a whole needs to have the ability to utilise both levels of learning. In other words, they should be able to correct their actions based on experiences, but also be able to question the foundations of common beliefs and norms. This requires for a common understanding and interpretation of the basic operating rules to exist between the partners.

2.3 Framework for organisational learning types

Inkpen and Crossan (1995) presents a framework for different types of organisational learning, originally developed by Crossan for studying organisational learning and strategic management (Crossan, 1991). In this framework, cognitive change and behavioural change are combined as different axes of a quadrangle and depending on the

type of learning, cognitive or behavioural changes take place. The framework is illustrated in Figure 1 and explained in more detail according to Inkpen and Crossan (1995) in the following.

When both cognitive change and behavioural change are missing, the framework suggests that no learning has occurred at all. On the other hand, when both cognitive and behavioural changes happen, this is seen as integrated learning. There are also different degrees of cognitive and behavioural change pictured in the other quadrants of Figure 1, as well as differences in the durability of the changes that are the result of learning. Integrated learning can be seen as the most desirable, because its effects are relatively permanent.

Figure 1   Types of organisational learning according to cognitive and behavioural change
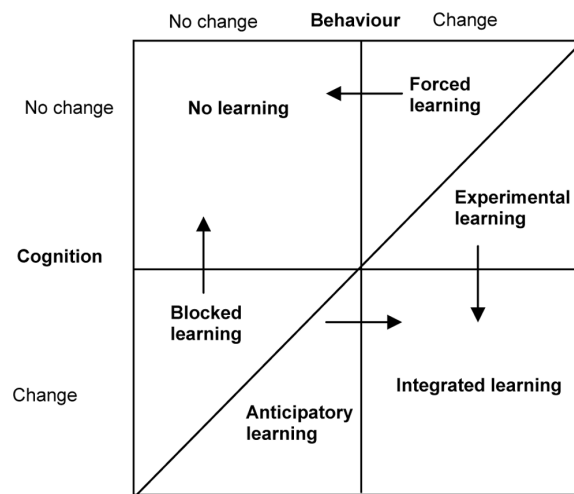
Source: Inkpen and Crossan (1995) and modified from Crossan (1991)

Forced learning, in the top right section, occurs when there is a change in behaviour but no cognitive change. The learner (the learning organisation) has been forced to change but does not change its own cognitive models. In experimental learning, the learner suspends its beliefs to try a new behaviour. If the experience with the new behaviour is positive, experimental learning can develop into integrated learning, where the change in behaviour also leads to a rather permanent change in cognition.

Blocked learning, presented in the lower left section, involves cognitive changes that do not lead to behaviour changes, because some conditions exist in the organisation that prohibit the change on behavioural level. Blocked learning cannot be observed from the outside and may not even be conscious. Anticipatory learning, in contrast, has changed the learner's cognition and may result in a change in behaviour or actions later and therefore turn into integrated learning. This means that the organisation has some internalised knowledge that recognises it as potentially useful.

Integrated learning, as described above, is learning that combines both cognitive and behavioural change. To achieve sustainable changes as a result of learning, there is a need for a balance between cognitive and behavioural components of learning.

The value of this framework is in the knowledge that different types of learning exist that combine the elements of behaviourism and cognitivism and that they can be used to

achieve different types of organisational goals. Integrated learning is seen as the predominant type for lasting effects and might thus be desirable, but there are conditions in which forced learning or anticipatory learning might work best in an organisation and be more suitable to achieve the wanted results.

When considering innovation activities in networks of organisations, it becomes important to recognise the need for different types of learning as well and which type of learning would be most suitable for the situation of the innovation network.

3 Views of inter-organisational learning

In the following, several theoretical views on organisational learning considered important from the inter-organisational perspective are presented. Finally, the theoretical views are combined with the framework of different types of learning and the implications to efficient learning in networked innovation are discussed.

3.1 Organisational learning theories and approaches from inter-organisational perspective

All of the selected views on inter-organisational learning presented in this paper (see Table 1) are often highlighted in the literature related to organisational learning, or specifically learning in networks. They have been referred to by many authors and have received attention in the areas of innovation and networks. They can be regarded as currently important or rising theories or viewpoints on learning, they all have a significant amount of empirical research behind them that has proved them to be valid in the scientific perspective, they can be considered to be rather fundamental and general perspectives that lie behind many other learning perspectives and they have been published in various important academic journals. We also deliberately include in this study different types of views to highlight the differences between them and to include possible implications from a broad spectrum of views.

The conversion of explicit and tacit knowledge (Nonaka and Takeuchi, 1995; Holmqvist, 1999) is based on the idea that the key to knowledge creation is in the mobilisation of organisational tacit knowledge and to enable this there is a need for conversion between tacit and explicit knowledge types in the knowledge creation processes. The knowledge creation processes between explicit and tacit knowledge are also needed between organisations, and should be designed in the beginning stage of a network.

Exploitative and explorative learning view (Levinthal and March, 1993; Nooteboom, 2004) suggests that organisational learning occurs primarily via organisational routines (i.e., actions, procedures, norms, and models). According to Levinthal and March (1993), organisational learning should aim to cope with the problem of balancing the competing goals of exploration, i.e., the development of new knowledge, and exploitation, i.e., exploiting current information, knowledge and organisational competencies. Much of this knowledge is embedded in the different organisational routines and procedures. Between organisations and networks, it should be noted that the importance of exploitation and exploration varies dynamically and dialectically in the different stages of the network relationship.

Table 1   Different viewpoints on inter-organisational learning and their implications
and supporting practices in networked innovation

View/perspective (Authors)	Implications for inter-organisational learning	Implications for networked innovation from the standpoint of effective learning	Examples of typical/specialised practices to support inter-organisational learning in innovation
Conversion of explicit and tacit knowledge (Nonaka and Takeuchi, Holmqvist)	Knowledge creation processes between explicit and tacit knowledge are needed also between organisations	Knowledge creation processes should be built in explicitly in both formal and informal innovation processes	• Identification and mobilisation of important tacit knowledge for the network • Formal processes: meetings, written documents and instructions, objectives for learning • Informal processes: possibility to share knowledge in an informal setting, employee-organised activities
Exploitative and explorative learning (Levinthal and March, Nooteboom)	Balance between exploitation and exploration varies in the different stages of the network relationship	The importance of routines for exploration increases as a source of innovation	• Identifying and evaluating the needed balance between explorative and exploitative routines in different stages of the relationship, need for more explorative and exploitative learning • Learning requires commitment, keeping the relationships alive on personal and organisational level
AC, relative absorptive capacity (Cohen and Levinthal Lane and Lubatkin Dyer and Singh)	Greatest potential comes from learning from teachers with similar basic knowledge but different specialised knowledge. Routines can be made more effective by enhancing partner-specific absorptive capacity (ability to absorb knowledge from specific partner)	Partners should possess similar types of knowledge bases, similar organisational structures and compensation policies, similar knowledge-processing style, as well as similarity in the companies' commercial objectives	• Identification of basic and specialised knowledge by taking stock of the existing knowledge base => possibility to evaluate similarity • Talking about objectives and future plans with the innovation partners; finding possible common present and future goals for network participants • Identification of one or more suitable participants as possible teachers
Organisational memory/ (Walsh and Ungson, Moorman and Miner, Koistinen)	Creation of interorganisational routines, and creation of formal and informal networks as well as databases etc.	Creation of common, commonly understood innovation processes and routines, as well as the creation of other important memory forms	• Creation of common organisational memory for the network as a goal • Modelling and describing current processes and routines of individual organisations, as well as formal databases • Transactive memory: important to learn efficiently who knows what. Centralised/distributed control. • Instead of copying processes from others, trying to create new processes together

Table 1 Different viewpoints on inter-organisational learning and their implications and supporting practices in networked innovation (continued)

View/perspective (*Authors*)	*Implications for inter-organisational learning*	*Implications for networked innovation from the standpoint of effective learning*	*Examples of typical/specialised practices to support inter-organisational learning in innovation*
Systems thinking (Senge, Sterman, Argyris)	Common and in-depth understanding of mutual interdependencies and the larger system the companies are part of. Continuous, regular feedback and approaches that support the utilisation of feedback are important	Enables questioning the existing mental models as well as creating radical innovations. Identifying the virtuous or vicious loops in innovation processes and taking advantage of the loops in questioning the present thinking, as well as in creating new ways to innovate	• Describing the network and its objectives together to establish a shared view of each participant's role in the network • Recognition and description of interdependencies of network participants • Establishing feedback processes in different stages of the innovation process • Designing the product, service and process architecture together with other network partners to minimise interdependencies and communication needs during innovation projects, for instance when the participants in networked innovation activities are located in geographically distant places or different countries • Identification of virtuous/vicious loops
Dynamic capabilities (Teece and Pisano and Shuen, Dyer and Singh)	Firm's critical resources (rare, valuable, complementary, hard to imitate) may extend beyond firm boundaries. Partnerships enable inter-firm learning by helping to recognise dysfunctional routines and develop them	Identification of critical resources in the innovation process. Strategic integration of complementary capabilities in innovation networks leads to better chances for radical innovations	• Recognising and describing own capabilities and critical resources, particularly knowledge-based resources from the network point of view; continuous re-evaluation • Developing routines together with partners

Source: Modified from Hallikas et al. (2009)

The idea of *Absorptive Capacity* (AC) *or relative AC* (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Dyer and Singh, 1998) is based on the similarity of previous knowledge to new knowledge. Previous knowledge enhances the learning of similar knowledge, and learning is most effective when the new knowledge is related to the existing knowledge. In a network, the greatest potential for learning comes from learning from teachers with similar basic knowledge but different specialised knowledge. Routines can be made more effective by enhancing partner-specific (ability to absorb knowledge from a specific partner) or relative AC.

According to the view of *organisational memory* (Walsh and Ungson, 1991; Moorman and Miner, 1997; Koistinen, 2003), organisations are assumed to create, use and store information and knowledge in a similar way as individuals. Learning occurs

via doing and experiencing and is stored in organisational work and core processes, as well as products, services or other constructed artefacts. Thus, between organisations, the creation of inter-organisational routines (formal or informal, e.g., social or business) and creation of formal and informal networks, as well as common databases and other forms of storing knowledge is important.

In *systems thinking* view (Senge, 1990; Sterman, 2000; Argyris and Schön, 1996), interaction and interdependencies are an important focus of interest to learning and feedback is an essential prerequisite for effective learning. Capability for systems thinking enhances the capability for double-loop learning. Senge (1990) defines the learning organisation as an organisation that is continually expanding its capacity to create its future. The capability to innovate and be innovative, as well as learning from the future can be, therefore, seen as fundamental elements of a learning organisation. It is important to recognise the whole structure of an organisational system and also to identify virtuous and vicious loops. In a network, the partners should have common and in-depth understanding of their mutual interdependencies and the larger system they are a part of. Continuous, regular feedback and approaches that support the utilisation of feedback are important.

Dynamic capabilities view (Teece et al., 1997; Dyer and Singh, 1998) is based on the ideas of the resource-based view of the firm and complementary assets, as well as the continuous ability to renew and adapt competencies dynamically through learning according to the changing situation. From the network point of view, an organisation's critical resources that are rare, valuable, complementary and hard to imitate may extend beyond firm boundaries. In this view, partnerships enable inter-firm learning by helping to recognise dysfunctional routines and develop them.

3.2 Organisational learning views in the cognitive/behavioural framework

Figure 2 presents all of the views on organisational learning in the cognitive or behavioural framework presented in the previous section, according to the authors' perspective on how the two components are shown in each view. This is done to reflect the fundamental orientation of each theory or view, according to whether they implicitly or explicitly emphasise change on behavioural or cognitive level. There are of course many ways to classify the presented views and thus the locations of the views in the figure are not exact but give an idea on the type and emphasis of learning they most likely resemble. Some of the views can be classified under multiple types of learning, and the important fact is that organisations should be able to combine and utilise several of the learning views simultaneously. The reasons for locating each view in the framework are explained in the following.

Starting from the top right corner of the quadrangle, where changes occur mainly in behaviour but not so much in cognition, the single-loop learning described by Argyris and Schön (1978) can be seen as forced or experimental learning, since it is based on changing behaviour without a change in the existing mental models (cognition).

The conversion of explicit and tacit knowledge (Nonaka and Takeuchi, 1995) can be classified into any of the learning types that change the behaviour of the learner or the learning organisation(s), depending on which stage of the conversion process is active. Thus, this view can be classified as forced, experimental or integrated learning.

Figure 2 Location of selected views on organisational learning within the cognitive or behavioural framework
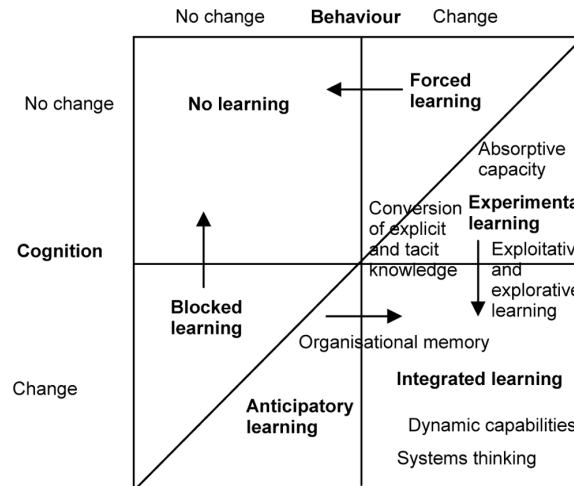
The AC and relative AC view (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Dyer and Singh, 1998) can be seen as changes that happen in the first stage in the behaviour of the organisations, when they look for partners. If the experience is positive and partners with similar knowledge are found, then also cognitive changes can happen. This is natural for experimental learning.

Also, exploitative and explorative learning (Levinthal and March, 1993; Nooteboom, 2004) can be seen similar to the above, although it might more easily turn into integrated learning, so it is pictured nearer to this category.

Moving to the lower right corner of the quadrangle, where both types of changes are possible, double-loop learning, according to various writers (Argyris and Schön, 1978; Senge, 1990), changes both the cognitive framework and the behaviour of the entity in question, so it is easy to see as a part of the integrated learning type. However, it can also be seen as anticipatory learning, since the changes in behaviour might come later than the change in cognition, meaning that it takes time to act on the change.

The organisational memory view (Walsh and Ungson, 1991; Moorman and Miner, 1997; Koistinen, 2003) is similar to double-loop learning in the sense that when creating a common organisational memory form, the cognitive capacity is also changed, and this enables changes in behaviour, either at the same time or later on. In any case, the organisation has created valuable and useful knowledge it might utilise.

The systems thinking view can be located as integrated learning, since it is a holistic approach to organisational learning, which changes both the cognitive and the behavioural level (Senge, 1990). Senge (1990) emphasises seeing and changing the structures (mental models, cognitive level) behind the actions (behavioural level), and Sterman (2000) sees feedback as a requirement for learning to take place.

The dynamic capabilities view (Teece et al., 1997; Dyer and Singh, 1998) is in this model located as an integrated type of learning, because it requires ongoing evaluation of the cognitive, mainly knowledge-based resources of the organisation and also immediate changes in the behaviour of the organisations according to the results of the evaluation.

3.3 Features of inter-organisational learning

As a synthesis of the presented views on learning, we have identified some fundamental features that can be found in several of the learning views. The similarities and differences of the selected views on learning in organisations and between organisations can be described at least with regard to the following factors and these issues should be considered when designing the learning approach in organisations.

Feedback process. Feedback is seen as a requirement for learning in many different approaches, but in some views it is left without attention and not seen as a critical requirement. However, in an organisational setting and especially between organisations, it is an important factor to take into account.

Routines. The results of learning can be stored in the behavioural routines of the organisation or network. The developed routines can also be seen as an outcome of the learning process, not only as a feature of the process. Routines are mentioned in several learning views, although an exact definition of the concept of routines has not been agreed on.

Mental models and assumptions. In some views, the existing mental models and underlying assumptions are changed as a result of learning, or in some models they are left unchanged. The situation of the organisation defines how great an ability to question the existing structures it should possess.

Knowledge integration. There are similarities and differences between different views on how they see the method of knowledge integration, how knowledge is integrated from individual to organisational and finally inter-organisational level. Coordination. How is the knowledge acquired by learning coordinated, to allow efficient use by different members of the organisation? Here, the basic choices are either centralised or distributed coordination. The same applies in the case of networks of organisations and is often complicated by the matter of knowledge ownership between the partners.

Knowledge in 'who knows what?'. Since the expertise and mainly tacit knowledge is distributed in the organisation between persons working there, the meta-knowledge on who possesses which kind of information is valuable and helps in utilising the knowledge. In networks of organisations, this knowledge has to be somehow managed and transferred between the organisations and between individuals working in the separate organisations.

4 Inter-organisational learning in innovation networks

In networks of organisations focused on creating innovations, there are several factors affecting the inter-organisational learning process and making it more complex. In this section, we evaluate the views presented on learning, according to their suitability and usefulness for inter-organisational learning in the innovation environment. In the latter part of the section, some suggestions for practices that can be used to support learning are given on the basis of the literature.

4.1 Suitability of the selected learning views in different situations

We cannot directly recommend any single approach to be used in specific situations, industries or other contexts in innovation. However, each studied approach covers some important aspects of learning and the different views and theories emphasise rather different types of approaches that should be paid attention to and focused on when organisations and networks aim to develop their learning abilities in innovation. No single standpoint or approach alone can provide a basis for effective learning in the case of any individual organisational network or any individual situation.

Effective learning with sustainable, long-term impact on organisational competitive advantage can be achieved most likely when various aspects and standpoints of learning are simultaneously taken into consideration when planning inter-organisational network cooperation. However, we have analysed more carefully when certain approaches of learning should be emphasised in the facilitation of learning in networked innovation.

Roughly speaking, the conditions affecting the emphasis of the learning approach can be divided into two categories:

- network-specific factors (internal for the organisational network; factors that the network and the individual network participants have a more direct influence on)

- factors concerning the business environment of the organisational network (external for the network; factors that the network has no influence on, or can influence only/mainly indirectly).

In this section, we evaluate the described learning approaches and their interrelationships with factors internal and external to the network.

Conversion of explicit and tacit knowledge. As this (or 'Nonakan') approach emphasises the mobilisation of tacit knowledge, its use should be emphasised particularly when a network operates in a field or an industry in which a significant amount of existing knowledge is tacit-based, or in which tacit knowledge has a particularly great importance for the business. Such cases include knowledge-intensive industries like ICT and biotechnology. On the other hand, industries that experience significant effects due to generation-change (such as the Finnish forest industry), or are in fear of losing critically important and rare tacit knowledge for instance in the form of rare experts or other specialist due to, e.g., pensioning or the result of head-hunting, should focus on Nonakan types of learning approaches. Such cases include e.g., hi-tech SMEs with narrow specialisation and few centrally important experts. Furthermore, networks that for certain reasons involve significant barriers for transferring tacit knowledge, such as international multi-cultural business networks (see e.g., Möller and Svahn, 2004), or virtual or 'imaginary' organisations (Holmqvist, 1999) and other networks that involve participants with large cultural or cognitive distance, like organisations with clear focus on utilisation of virtual teams (Martins et al., 2004) from different organisation-cultural or other cultural backgrounds, should focus on this approach.

Exploitative/explorative learning. According to Gilsing and Nooteboom (2006), exploitation implies the focus on incremental innovations and codified knowledge, as well as rather formal, stable and delocalised networks, while exploration usually implies more focus on radical innovations and tacit knowledge, together with informal, unstable/dynamic and relatively locally embedded networks. These focus areas should

also be strongly reflected in the way that organisational and inter-organisational learning activities are carried out: for instance, exploitation requires relatively low frequency of interaction, contract or institution-based trust and single-loop learning, while exploration relies more on higher levels of interaction, personal or relation-based trust and double-loop learning (Gilsing and Nooteboom, 2006). The balance between exploitative learning and explorative learning and the related learning-oriented activities should be continuously re-evaluated, as exploitation and exploration are dialectical and dynamic processes. In particular, the re-evaluation should be carried out regularly when the networked operations or the network maturity, the business and the markets of the network, or the products of the network develop rapidly. According to Nooteboom (2004), the future uncertainty of structural change should be taken into account in networks of exploration, as it requires the innovation of new business concepts, products, and services (Hallikas et al., 2009). In networks emphasising exploitation of present knowledge, the benefits of more static efficiency are sought after.

Absorptive Capacity (AC). AC-based or relative AC-based learning, and the commonality of potential partners, should receive particular attention when companies or networks are planning to outsource some of their R&D-related activities or competencies (e.g., when globalising their activities and R&D) and e.g., when an organisational network or its individual participants need to look for new ways of cooperation or suitable new close partners either from inside or outside the network. In such outsourcing situations, there is also a risk of outsourcing a part of a firm's and networks learning capability (i.e., AC). In addition, according to Lane and Lubatkin (1998), relative AC may also be useful in leveraging a firm's core competences across its business units especially in complex, transnational corporations (see Cohen and Levinthal, 1990; Lane and Lubatkin, 1998).

Organisational memory. Generally speaking, the development of various forms of organisational and common inter-organisational memory forms is important in all network types that really aim to adopt a networked way of operation in innovation. However, e.g., according to Koistinen (2003), when the complexity of commonly developed products or the business setting increases significantly, there is a need to emphasise particularly the development of business and social routines as specific forms of organisational memory. On the other hand, for instance when the roles and the core competencies are not carefully determined and understood collectively, or they are very challenging to be defined explicitly considering the overall goals of the whole network, the form of organisational memory called transactive memory (who knows what in the network) should be carefully emphasised in the development of the network. An example of a networking form in which the role of transactive memory is further emphasised is 'the communities of practice' (Wexler, 2002).

Systems thinking. The systems thinking approach is particularly relevant when the organisational network is complex, it includes various and complex interrelationships between the network actors, or the boundaries of subsystems within the network or larger systems outside the network are not well defined and understood by the network participants. The recognition and definition of virtuous loops should be paid attention to when the competition is hard, and when there is a significant need to support the recognition and creation of various sources for sustainable competitive advantage. The recognition of vicious loops is important for instance when innovative activities and product development are jeopardised by continuous fire-fighting and emphasis on

short-term instead of long-term planning, for instance in networks characterised by complex multi-project environments (Repenning et al., 2001). In addition, systems thinking approaches should be adopted when the network has a need to shorten the development time by moving into more parallel type of innovation processes and accordingly, when the related product and process architectures should be modularised to minimise the inter-dependencies and communication needs during innovation projects, for instance when the participants in networked innovation activities are located in geographically distant places or different countries. Double-loop learning should be emphasised instead of mere single-loop learning, particularly when there is a clear need for more radical innovations (McKee, 1992) in the network firms, for instance in the case of very novel industries or markets, or very mature industries that feel the need for growth by new types of innovations.

Dynamic capabilities. This approach to learning should be emphasised particularly when the networks face markets, competition and business environments that are relatively highly turbulent, weakly predictable and fast-changing (Teece et al., 1997), such as in the electronics and ICT industries. Also, when the capabilities and resources of the network are not easy to coordinate, for instance when it is not easy to define the core competences of individual network participants for efficient definition of the expertise-based roles of the network, this approach should be paid special attention to.

4.2 Practices for supporting inter-organisational learning in innovation

In the following, we present some examples of general practices or actions in organisations and networks that can be seen as important and are typical for each of the selected organisational learning views, especially when applied to inter-organisational learning and innovation (see Table 1). These practices can be used for supporting effective inter-organisational learning in innovation activities.

The conversion of explicit and tacit knowledge highlights the importance of mobilisation of tacit knowledge and building the processes for knowledge creation. This means that the participants in the network need to be able to identify the important tacit knowledge from the network point of view and to create both formal and informal processes to enable the flow of information. The formal processes can be meeting procedures, documents or instructions, or for example documented objectives for learning. Informal processes give the possibility to share knowledge in informal settings, for example events that only focus on people getting to know each other and these can even be organised by the employees themselves.

The exploitative and explorative learning view assumes that the routines needed for learning change with time and the suitable balance between exploration and exploitation needs to be evaluated in different stages of the network development. Learning also requires commitment between the partners to keep the relationship alive.

The AC view implies that the similarity of the knowledge base plays an important role in learning between partners, so the identification of the company's own basic and specialised knowledge gives a starting point to evaluate similarities between partners. Also, future goals and plans should be considered and maybe modified to find possible common goals in the network.

The organisational memory view sets the creation of a common memory for the network in different forms, such as routines and databases, as a goal, and thus every

member of the network should be able to identify and describe its current processes and routines. As part of the organisational memory, also the knowledge about who possesses certain kind of knowledge (transactive memory) is important. In a network, developing new processes and routines is important, not only copying existing processes.

The systems thinking approach emphasises seeing the bigger structures and in this case it means the ability to describe the network and the role of each participant, as well as the interdependencies between the partners. The aim is to establish a shared understanding of the network to allow efficient learning and also establish feedback processes in different stages of the innovation process. The identification of virtuous and vicious loops can also be utilised. In innovation activities, it is possible to design the product, service and process architecture together with other network partners to minimise interdependencies and communication needs during innovation projects, for instance when the participants in networked innovation activities are located in geographically distant places or different countries.

The dynamic capabilities view requires that the critical and valuable resources in the network are identified, also from the network point of view and re-evaluated regularly to enable necessary changes. Learning is based on improving and developing routines, and this can also be done together with the partners.

ICT tools can be seen as an essential element in supporting effective learning in various ways when considering the presented learning views and applying them in innovation networks. In the conversion of explicit and tacit knowledge, ICT can facilitate, in the context of product development and innovation, especially the producing and sharing of explicit knowledge between partners (e.g., Boutellier et al., 1998). However, the current communication technologies can also quite effectively facilitate the accessing, utilisation and sharing of tacit knowledge (e.g., Benbya et al., 2004), and in a limited manner, even the development of the important prerequisite for tacit knowledge transfer, the development of trust (e.g., Järvenpää and Leidner, 1999), e.g., by the use of video conferencing tools and a suitable combination of other current and emerging technologies (such as blogging and wikis). To achieve this, the combination of technologies must allow for sufficient media-richness of virtual communication (e.g., Rowe and Struck, 1999). The exploitative and explorative learning view can also be supported by ICT systems and e-learning in both phases of the learning, when the aim is either to process the existing knowledge or to explore new knowledge.

In the view of AC, the role of ICT is not so clear, but it can be seen as mainly supporting: for instance, the varied existing ICT-based technologies and e-learning technologies can offer very useful support for inter-organisational virtual meetings and virtual teams. This allows the networked organisations to utilise and combine the best available competencies and experts (see e.g., Martins et al., 2004), despite the barriers concerning the physical distance and their knowledge to develop even totally new competencies, thus improving also the AC of the innovation network. Organisational memory can be greatly facilitated by the use of ICT, especially when describing and modelling the organisational and inter-organisational innovation-related routines and storing the acquired knowledge in databases and knowledge bases. In the inter-organisational, and consequently, in the virtual team context, the important transactive memory form of organisational memory can be facilitated with the suitable use of virtual and Knowledge Management System (KMS) technologies (e.g., Alavi and Tiwana, 2002). The systems thinking approach highlights the importance of a holistic picture of the situation, which can be made clearer to all the partners in the network

by using various ICT tools to model the situation and to agree on common language, as well as using simulation tools and system dynamics models (e.g., on the 'bullwhip effect' in the supply network, see Sterman, 2000) to enable better learning. Also, the dynamic capabilities view of learning, which is based on the unique capabilities the network and its participants have, can be supported by ICT for instance by describing the capabilities and making them visible to all involved.

5   Conclusions

An organisation's ability to learn faster and better has become an essential element of competitive advantage. The increasing interconnectedness and complexity of the business environment requires effective learning, both within and between organisations.

In the pursuit of competitive advantage, learning in the context of innovation and innovation-related networks is a particularly challenging but increasingly more important task for companies. Efforts put into the development of inter-organisational networks that support effective learning in innovation can provide a basis for a relatively sustained competitive advantage for companies. We have found very few papers on the subject of learning in inter-organisational networks in the existing literature.

In this paper, we have studied organisational learning from the standpoint of inter-organisational networks and innovation. Instead of exploiting just one standpoint on the topic, we have studied this subject from the standpoint of diverse views and theories.

In the literature, there are various views on the concepts of learning and organisational learning. We have selected and described different currently important or risingly important approaches and views on organisational learning that are particularly relevant from the standpoint of networked innovation, as well as having a significant amount of empirical research behind them, proving them to be valid in the scientific perspective. The approaches can also be considered to be fundamental and general perspectives that lie behind many other learning perspectives, as well as e.g., the concept of e-learning.

We have analysed the different learning approaches and views concerning their fundamental learning orientation with respect to cognitive and behavioural learning, with the help of an analytical and illustrative framework by Crossan (1991), and concerning their suitability in various situations and conditions of innovation networks. Concerning the managerial perspective, we have also suggested pragmatic guidelines to be considered in each type of learning approach (see also Table 1 in the Appendix).

Since innovation is a particularly challenging and important task or process from the standpoint of knowledge creation and innovation, several standpoints should be recognised and used when aiming at effective learning. Attention should be paid to the effective facilitation of learning, particularly in information – and knowledge-intensive industries, the competitiveness and future of which depend on their ability to learn and to renew themselves.

On the basis of this study, it can be said that effective learning with sustainable, long-term impact on organisational competitive advantage can be achieved most likely when various aspects and standpoints of learning are simultaneously taken into consideration when planning inter-organisational network cooperation.

Even though we cannot directly recommend any single approach to be exclusively used in certain types of situations, industries or other contexts in innovation, we found

clearly that several network-specific internal and external factors affect the suitability and emphasis of selected inter-organisational learning approaches. Each studied learning approach seemed to cover some important aspects of learning, and the different views and approaches emphasise different types of organisational learning that should be paid attention to and focused on when organisations and networks aim to develop their learning abilities in innovation.

From the standpoint of effective knowledge creation, accumulation and learning in innovation networks, it is important for managers to clarify network-specific and external factors that affect the choices of suitable learning approaches and their mutual emphases, and attempt to build, suitable learning practices into their organisations.

Finally, it should be noted that in the context of organisational and particularly inter-organisational learning, the role of ICT as well as the various methods of e-learning are of particular importance. However, as an important managerial implication of this study, for companies to be able to utilise and select various ICT tools and e-learning methods efficiently to support inter-organisational learning, they should be well aware of different viewpoints and approaches to inter-organisational learning, the different network-specific factors affecting the suitability and relevance of the various learning approaches, as well as the learning practices to be considered in the case of each learning approach. Our further research based on the results of this study concerns the use of ICT in inter-organisational learning, considering the studied approaches to inter-organisational learning.

Acknowledgement

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Publication IV

Challenges and practices for learning within and by innovation networks

Hannele Lampela*

E-mail: hannele.lampela@lut.fi

Matti Kuvaja

E-mail: matti.kuvaja@phnet.fi

Anna Kyrki

E-mail: anna.kyrki@lut.fi

Hannu Kärkkäinen

E-mail: hannu.karkkainen@lut.fi

Kalle Piirainen

E-mail: kalle.piirainen@lut.fi

Lappeenranta University of Technology, P.O. Box 20, 53851
Lappeenranta, Finland

* Corresponding author

Abstract: In this study, the challenges and practices for learning are discussed from the point of view of innovation networks including both theoretical and empirical views. A distinction is made between learning within networks and learning by networks, depending on who is seen as the learner. Based on content analysis of nine interviews within three networks, the challenges for learning are identified on organizational, dyad, and network level, and the identified network learning practices are connected to several theoretical viewpoints on learning. The study brings new understanding of organizational learning from the perspective of networks, and the categorization of learning challenges and practices for learning between multiple organizations help managers to recognize important issues and show possibilities for developing more systematic support for learning also on the network level through several types of practices.

Keywords: Network learning; innovation networks; product development; service development; co-operation; learning challenges; learning practices

1 Introduction

The ability to innovate has been recognized as an important success factor for organizations [1]. Continuous innovation requires also the ability to learn, to create or assimilate new knowledge fast and to utilize it effectively. The competitiveness of organizations is increasingly dependent on their ability to learn and assimilate knowledge, especially in dynamic market conditions [e.g. 2]. Networking and co-operative arrangements provide an opportunity for organizations to acquire and integrate new knowledge from external sources to their existing stock. This paper addresses the topic of learning and innovation networks, where more than two partners co-operate and learn together.

Organizing innovation activities in networks between several partners is becoming increasingly common in different industries. The reasons for this development are for example gaining access to resources, knowledge, skills, or markets previously unavailable, and sharing the high costs and spreading risks related to innovation activities. The pressure for faster time to market and need for speeding up the development projects, enabling product differentiation and concentration on core competencies are making companies realize that they cannot manage alone the vast variety of resources and capabilities needed for satisfying customers in increasing competition. The globalization of market and acceleration of technological progress particularly speed up co-operative innovation activities. Access to external resources and markets are not only sought for economies of scale, but also to gain new complementary knowledge assets and to utilize different specialization areas of partners, share knowledge and to learn from the partners. [3], [4], [5], [6], [7]. Networked innovation is one phenomenon under the umbrella of Open Innovation (OI) paradigm, which was originally presented by [8].

The potential co-operation partners include research institutes, suppliers, competitors, customers and other external parties. Co-operation arrangements can have various forms from strictly formal long-term partnerships managed by agreements, to less formal and need-based short term agreements. In this research, joint ventures and other equity-based arrangements are limited outside the scope of the study, because there is substantial literature about learning within this kind of strategic alliances (see e.g. [9], [10], [11]). Depending on the type of product and risks involved, the details of the arrangements and organization of the development projects are very context-dependent. Large and risky technology-intensive projects typically call for a joint effort. Research shows that particularly in product development related co-operation, the organization of governance structure and defining the scope of the co-operation are important [7].

As theoretical starting points, the paper utilizes innovation management literature as well as inter-organizational learning literature, concentrating on learning by networks of several partners rather than between two partners. Organizational learning has been a popular topic in recent years and learning has been connected to studies in different fields [12]. Mainly the research has been focused on organizational learning within a single organization (organization as a learner) or on strategic alliances or other partner agreements in a dyadic relationship between two partners (one- or two-directional learning), not so much on learning by networks (several partners learning together) [13]. The interest in network level learning has been rising only recently. Also, several viewpoints and concepts related to organizational learning such as organizational memory [14], [15], absorptive or relative absorptive capacity [16], [17], [18], tacit and

explicit knowledge [19], [20], [21] or exploration and exploitation processes [22], [23] have been discussed in the literature separately, but a more holistic picture of the learning process and factors related to it has been missing.

The factors related to the learning process have not been studied in detail especially on network level, and tools and methods to support learning in and by networks are limited as well as practical examples of these [13]. Learning in general has been studied in many fields in recent years, but not so much in connection with innovation activities and projects [24]. Thus, the purpose of the paper is to produce a more detailed picture of inter-organizational learning, especially network learning in innovation activities, by providing both theoretical and empirical views on the subject. First, we identify the challenges related to learning in innovation and some important theoretical viewpoints in the learning literature. Secondly, we try to find some empirical counterparts for the theoretical concepts, concentrating on the network level. The objective is to identify challenges related to learning within and by networks, and to find examples of practices for learning in innovation.

The research is based on a theoretical overview together with a short summary of empirical cases. The theoretical part of the paper starts with an overview of general challenges in learning related to innovation, then identifies important factors and concepts in inter-organizational learning literature in the context of innovation, and based on these findings presents ideas on practices for network learning. In the latter part of the paper, empirical case data is presented and analyzed and finally in the conclusions part, a discussion of both the theoretical and empirical findings leads to offering theoretical and managerial implications.

2 Viewpoints on learning in innovation

Overview of general challenges in learning related to innovation

The special features of innovation activities compared to other activities in organizations, the inherent complexity of innovation processes and the knowledge intensity [25] mean that they are among the most challenging and critical processes from the standpoint of new knowledge creation and effective learning. The innovation activities and processes are particularly challenging for learning because they include multiple actors and process steps interacting with each other, which leads to increased complexity in coordination [1]. The tight interdependencies between various agents and process steps, limited and incomplete information, long time delays before the results of decisions and actions can be observed and feedback can be received, long physical distance from actions to their effects, and missing or misperceived feedback from decisions and actions are other identified challenges (see e.g. [25], [26], [27]).

A further challenge from the standpoint of learning is that the knowledge and information related to innovations, such as market and customer information, becomes outdated relatively quickly compared to other organizational information. In researching barriers for learning from market information in new product development, researchers have identified three types of organizational learning barriers: focusing on easy to understand information, narrow view and sub-optimization of goals, and inertia, i.e. tendency to maintain the status quo [28]. Also the heterogeneity of knowledge between

partners can present a challenge, since there needs to be a fit between the knowledge bases to enable efficient knowledge creation and exploitation [29]. Finally, learning is one of the motivations for co-operation between partners, but on the other hand the risk of technological leakage, the unwanted transfer of knowledge, is real in collaborative innovation [5], [7].

Approaches and practices for inter-organizational learning in innovation

The academic literature on networks, utilizing several perspectives and disciplines, has grown very rapidly during the last few years, and the importance of networks for organizational competitiveness has been recognized in these studies quite broadly. Similarly, the research on organizational learning has been well-established, and there is an extensive amount of related literature studying organizational learning from a multitude of perspectives – in the organization-centered view, organizational learning is considered to be more than the sum of the learning of individuals or groups that constitute the organization. As a result, the uses of the term organizational learning (OL) vary widely, from the learning of individuals in the organizational context to an organization-level standpoint that is clearly distinct from individual learning. In OL literature, the concepts of individual, group and organizational learning are long established. In recent literature, however, it has been argued that also a fourth level of learning, the level of inter-organizational network, might be relevant, useful and distinct from the other three levels. Thus, the concept of network learning - learning by a group of organizations as a group - has been presented (e.g. [13], [30], [31]). On the basis of found literature, empirical research is clearly needed to develop our understanding of this potentially important concept.

Most of the literature is based on empirical research reporting organizations' efforts to learn through their interactions with others (e.g. [13], [32]). Knight et al. ([13], [30], [31] argue that such research is almost exclusively about learning within networks ('inter-organizational learning'), not learning by networks ('network learning'). According to [13], if a group of firms change the group's behaviour or cognitive structures, through their interaction, it is the group of organizations that is the 'learner', not just the individual organizations within the group, and thus, the network can be said to have learnt. Network learning is, however, closely inter-related with organizational learning by network members, but still, these concepts are quite distinct in nature. Thus, learning by inter-organizational networks can be considered to be more than the sum of the learning of individuals, groups, or even member organizations that constitute the inter-organizational network.

To study this relatively novel topic with little empirical research from several perspectives, particularly when considering the context of innovation in networks, and to create a more holistic picture of the phenomenon, we have selected six divergent approaches to represent theories and methods relevant to the topic of inter-organizational learning and particularly network learning in the innovation context.. The selected approaches are: organisational memory, absorptive and relative absorptive capacity, conversion of explicit and tacit knowledge, learning flows of exploration and exploitation, systems thinking and feedback, and dynamic capabilities. All of the selected approaches and views are highly relevant and useful for network learning and are often highlighted in the literature related to organizational and inter-organizational learning. In

relation to each other, each of the above approaches provides a complementary perspective.

According to organizational memory view [14], [15], organizations are assumed to create, use and store information and knowledge in a similar way as individuals. Learning occurs via doing and experiencing, and is stored in organizational work and core processes, as well as products, services or other constructed artefacts. In a network, the creation of inter-organizational routines and formal and informal networks as well as common databases and other forms of storing knowledge is important. Absorptive capacity and relative absorptive capacity view [16], [17], [18] are based on the similarity of previous knowledge to the new knowledge. Previous knowledge enhances the learning when the new knowledge is related to the existing knowledge. In a network, the greatest potential for learning comes from learning from others with similar basic knowledge but different specialized knowledge. Conversion of explicit and tacit knowledge [19], [20] is based on the idea that the key to knowledge creation is in the mobilization of organizational tacit knowledge, and to enable this there is a need for conversion between tacit and explicit knowledge in knowledge creation processes also between organizations.

Explorative and exploitative learning [23], [33] suggests that organizational learning occurs primarily via organizational routines. According to [33] organizational learning should aim to balance between exploration, i.e. the development of new knowledge, and exploitation, i.e. exploiting current knowledge. In systems thinking [34], [35], [36] interactions and interdependencies are an important focus of interest to learning, and feedback is an essential prerequisite for effective learning. In a network, the partners should have a common and in-depth understanding of their mutual interdependencies and the larger system they are part of. Continuous, regular feedback and practices that support the utilization of feedback are important. Dynamic capabilities view [37] is based on the ideas of the resource-based view of the firm [38] and complementary assets. The continuous ability to renew and adapt competencies dynamically according to the changing situation happens through learning. From a network point of view, unique resources that are rare, valuable, complementary and hard to imitate may extend beyond organizational boundaries. Partnerships also enable learning by helping to recognize dysfunctional routines and develop them together.

Some ideas of practices for network learning between several partners in networks, connected to different viewpoints, are presented below in Table 1, and discussed in more detail in [39].

Table 1 Theoretical viewpoints and practices for network learning

| *Theoretical viewpoints of learning*	*Practices for network learning*
Organizational memory	Creating common forms of memory for the network (shared routines, databases etc.) and identifying and describing current processes and routines. The knowledge on who knows what (transactive memory) is important. Depending on the objectives of the whole network, the forms of organizational memory forms should be carefully designed.
Absorptive capacity, relative absorptive capacity	Identifying own basic and specialized knowledge gives a starting point to evaluate similarities between partners in the network.

Tacit and explicit knowledge	Identifying the important tacit knowledge from the network point of view, and creating both formal (meeting procedures, documents or instructions, or documented objectives for learning) and informal processes or events (e.g. getting to know each other).
Exploration and exploitation learning	Considering the whole network's objectives, suitable balance between exploration and exploitation needs to be established in different stages of the network development, as well as in the different network member organizations.
Systems thinking and feedback	Describing the network and the roles of each participant, as well as the interdependencies between the partners. Establishing a shared understanding of the network and establishing feedback processes to allow efficient learning in the different stages of the innovation process.
Dynamic capabilities	Identifying and re-evaluating critical and valuable resources and capabilities as well as complementary resources and capabilities from the network point of view to enable necessary changes. Improving and developing routines together with the partners.

More pragmatic forms of approaches and practices for inter-organizational and network learning are listed by Heikkilä et al. [40].These include e.g. workshops and brainstorming sessions with different sets of participants, scenarios, role play (making abstract ideas more concrete by exchanging roles between parties), benchmarks that serve as analogies e.g. from related industries, and stories and anecdotes.

3 Research design and methods

This research presents three cases of inter-organizational networks to understand the learning challenges that the partners have especially between several actors in the network. Also, the cases show how the representatives of the organizations see the different learning viewpoints expressed in practice. Qualitative text-based content analysis which is defined as "qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" [41] was used as an analysis method, to systematically organize and classify the empirical interview and document data, and finally to help in identifying and organizing important factors related to learning that were brought up by the material. Qualitative content analysis is a systematical method that can help to find patterns or themes in the data analysis which would not necessarily come up in a more impressionistic, heuristic analysis process. It suits well in situations where the research subject is abstract, new or otherwise not well known, as a form of conceptual analysis. Content analysis aims to describe the studied phenomenon in a concise and abstract way, and produces categories to describe the phenomenon. Figure 1 below shows the research design and analysis process in more detail.

Figure 1 Research design and analysis process
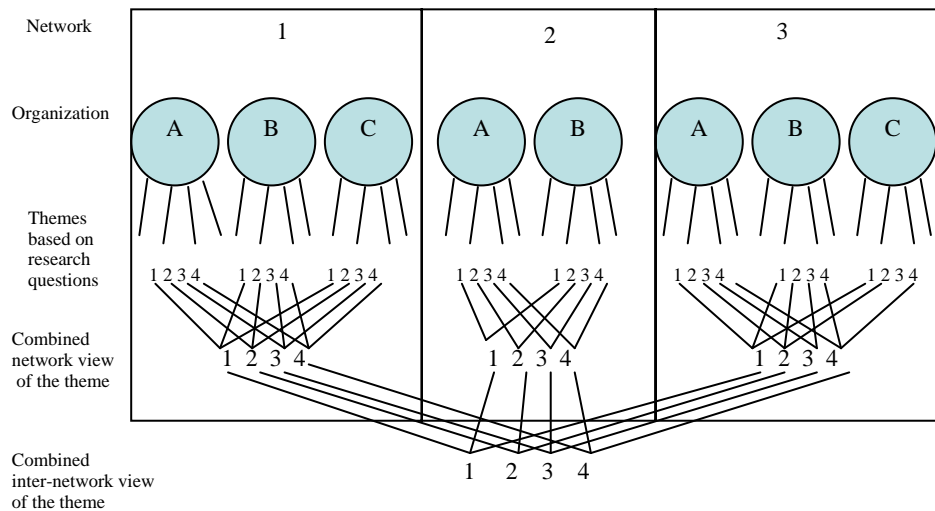
The empirical data consists of altogether nine individual semi-structured theme interviews [42], performed and analyzed by multiple researchers together to enable multiple views and researcher-based triangulation. The interviews were carries out in southern Finland in February and March 2008. The interview themes were based on the research questions and literature, and the results reported in this paper concentrate especially on the challenges and practices for learning. The interviews were taped with the permission of the interviewee and the researchers also took notes from the interviews, which typically lasted about 90 minutes. Publicly available electronic and paper documents such as annual reports and websites of the organizations were used as a secondary data source after the interviews to complement the material.

Altogether eight companies or organizations within three networks participated in the research. They had long experience of different types of inter-organizational co-operation related to innovation processes, and thus were seen as potential informants on the research subject. Within the networks, the organizations represent different fields of operation, although they are all considered as machinery and equipment industry companies. To produce a more versatile picture of the research subject, there are several interviews within the same network to include different organizations' perspectives. The network structure and coordination in each network varies, and the roles of the participating organizations vary from the end customer to system level supplier, component supplier, or research partner.

The respondents are middle to top managers involved in R&D or similar networked development activities (see Table 2 for further details on the interviews). The first respondents from a network were chosen based on the company profile and prior contacts, and the rest of the interviewees were found by asking the previous interviewee for more contacts who have experience on the area of the study. This is an example of the so-called snowball selection procedure [43], where the expertise and referrals of the other respondents are used to find the suitable respondents.

Table 2 Background information of the interviews

Interview/ network	Role of organization in the network	Role of interviewee
1A	System level supplier, manufacturer	Vice President, Operations
1B	End customer	Director, Technology and Product Management
1C	Component supplier	Development Manager
2A	End customer	Vice President, Technology and Operations
2B	Engineering partner	Development Manager
3A1	End customer, product development	Vice President, Global R&D
3A2	End customer, service development	Assistant Vice President, Service Innovations
3B	Development partner	R&D Manager
3C	Research partner	Head of unit

The interviews were transcribed and all the researchers analyzed and coded the transcripts of the two first interviews according to the research questions. In the analysis, data from the interviews were coded under four studied interview themes (1) description of the co-operation (2) challenges, particularly in learning (3) general support for learning (4) expressions of practices related to a distinct learning view. Later, themes 3 and 4 were combined. The rest of the transcripts were divided between altogether four researchers so, that each of them concentrated on interviews within one network, and coded them. The coded texts were then organized and classified according to the themes, and categories within the themes were created from the short expressions used to describe a theme. The results from individual interviews within a network were then combined to a broader category to represent a theme within the network, and in the final stage the results from different networks were combined, to form a collective view based on the cases and find some preliminary similarities and differences.

4 Empirical cases on learning challenges and practices

Descriptions of case networks

The three companies in network 1 operating in metal industry have a common history as previously part of the same organization. The co-operation has developed over time and is partly based on long-term personal relationships. The model of operation has been similar through the years, based on customizing existing products according to customer needs. One of the basic elements in the co-operation is a clear definition of roles and division of work. The trust and appreciation of each others' work has been proved in practice, which helps in limiting risks. A big challenge is the retirement of the personnel, because in the tight job market situation it is hard to get new people in and teach them the same kind of co-operation model. Personal relationships have a crucial importance and this may be hard to replace with modern information systems.

Companies in network 2 are the end customer who manufactures machines and equipment for wood products industry, and their design engineering partner. The co-operation is loose, and varies by situation, although the end customer has outsourced a lot of its operations but wants to maintain the core engineering and development work within

the company. Co-operation with partners in R&D happens mainly through developing existing products to better fit the end customer needs and is project-based rather than continuous.

Network 3 consists of an end customer in elevator and lifting equipment field, where two interviews from different functions were conducted, and two partners of the end customer in different roles: a non-commercial research partner and a development project partner. The co-operation network of the end customer is wide, and varies from project to project as well as the way of organizing co-operation. They emphasized a process view of operations, also with partners.

Challenges for learning

The results of the content analysis of the empirical interview material are presented as a summary of different types of challenges recognized as well as the identified practices for learning concerning each theoretical viewpoint of learning. The results are combined in Tables 3 and 4.

The levels of analysis for the challenges are organizational, dyadic or single partner level and inter-organizational network level with multiple partners, and the paper concentrates especially to challenges identified for network learning, although also dyad level challenges are discussed briefly below. The analysis of the challenges started from the coded transcripts of the interviews, where original expressions of the challenges in each interview were marked. Short descriptions of each challenge were formed and they were then grouped together with the similar expressions in the same network. Subcategories or groups of similar challenges were then identified, and collected together from all networks. Finally main categories were named and organized according to the level related to which the challenge primarily was mentioned. The challenges were not necessarily mentioned by the interviewees as related to a specific level of operation, and the same challenges might occur on several levels, so the division is partly based on researcher interpretation and strict limits between the levels do not exist.

On the organizational level, the categories of challenges formed on the basis of the different types of challenges identified in the interviews were related to knowledge management within the organization (e.g. losing know-how), functional challenges regarding different operations (e.g. separation of functions) and the external environment (e.g. changes in the environment). On the dyadic partner relationship level between organizations, the challenges were categorized as antecedent of knowledge transfer (e.g. trust and commitment), knowledge transfer and communication (e.g.communication and co-operation), partnership management (e.g. developing partnerships) and contracting (e.g. intellectual property rights (IPR) issues). The individual challenges recognized on a dyadic partner relationship level were for example the motivation to co-operate, incidental sharing of knowledge and recognizing the capabilities of new partners.

Table 3 Challenges of learning in networked innovation (each network identified with superscript numbers)

Level of analysis	Categories of challenges	Groups of challenges	Examples of short descriptions
Organizational	Knowledge management	Losing know-how[1,3]	Personnel turnover Production know-how
	Functional challenges	Separation of functions[1]	Different language used in functions
		Product development[2,3]	Long age of product generations Globalization
	External environment	Changes in operating environment[1,3]	
Dyadic partner relationship	Antecedents of knowledge transfer	Creating common understanding[3]	Special language used within organizations
		Trust and committment[1,2]	Willingness to cooperate
	Knowledge transfer and communication	Communication and co-operation with partners[1]	Companies in their own "camps" Incidental sharing
		Sharing knowledge[2,3]	Lacking interest to develop
	Partnership management	Shared development work[1]	Recognizing partners' capabilities
		Finding suitable partners[3]	Maintenance needed Sharing profits
	Contracting	Developing partnerships[2]	Conflict of protecting and sharing knowledge
		Agreement issues[2,3]	
		IPR issues[3]	
Network of multiple partners	Sharing knowledge in the network	Sharing knowledge[1]	Learning between multiple partners
	Competition & co-opetition	Competition[1,2,3]	Fear of spillovers of knowledge
		Co-opetition[1,2]	Competing companies in the network
	Network operation	Leadership in network[1,2,3]	Missing leaders
		Changing practices[1,2]	Passive networking
		Understanding of customer needs in the network[2]	Customers' customers' needs, holistic view

On the network level between multiple partners, the challenges were categorized as sharing knowledge in the network, competition and co-opetition and challenges related to the network operation (e.g. leadership in network). On the network level, detailed challenges related to sharing knowledge included challenges in learning between multiple partners. This was due to difficulties in disseminating information and the vast amount of information which is hard to manage. Competition was mentioned as a challenging issue on the network level by interviewees in all the networks, for several reasons such as fear of unwanted spillovers of knowledge and even industrial espionage. Related to that, also the theme of co-opetition or the challenges related to many competing companies

operating in the same network was mentioned as a limiting factor for sharing knowledge and thus affecting learning.

Concerning network operation, there were several kinds of challenges identified. Many of them were related to leadership in the network, which was seen as a challenge affecting network learning by respondents in all the networks. This challenge was characterized as missing leaders, uncertainty of who coordinates the network, or need for new practices in managing the network. The lack of clear leadership affects the possibilities for learning because the communication within the network is sporadic and responsibility for developing the network is unclear. Regardless of the role of the respondent's organization in the network (end customer, component supplier, system supplier etc.) the same challenge of coordinating the network activities became obvious. Another network level challenge was that networks were seen as a relatively new way of operating, and this requires for example changing the existing practices and ensuring the sufficient level of knowledge of the network partners, which is seen as challenging also from learning point of view.

Finally, a special challenge for the network learning is understanding customer needs, because due to the changes in the operation mode towards networked innovation companies need to know something about not only their direct customers' needs but also about the customer's customers' needs, and be able to forward this information further to their other partners. Especially in innovation networks this poses a significant challenge to information sharing since the possibilities to see and anticipate the customer needs wider in the network might be limited.

Learning viewpoints and practices

A similar content analysis process as for the challenges, based on the transcripts of interviews, was used to find and categorize the expressions of practices related to the selected theoretical viewpoints of learning, concentrating especially on dyadic partner or network level. The results of the analysis are presented in Table 4 below. The analysis started with the original expressions and short descriptions, to identify groups or sub-categories. Main categories were derived from literature according to the principles of theory-driven, deductive content analysis concerning the selected theoretical viewpoints of learning, and the categories were then organized within each of the six viewpoints. The connection of a specific item to network level was not explicit in all cases, so it might refer to dyadic level as well, and similar practices might have been mentioned in connection with several viewpoints of learning.

In the Table 4, for organizational memory, the categories were formal storage form (e.g. processes, databases, documents) and informal storage form (e.g. personal memory, history), for absorptive capacity view the similarity of organizations (e.g. objectives, using formerly known partners) and differences between organizations (e.g. different roles, complementary capabilities). For the exchange of tacit and explicit knowledge, the categories were events (e.g. meetings, trainings), personal experiences (e.g. people moving tacit knowledge) and formal structures (strategy and processes). The expressions of exploitation and exploration in learning were categorized in acquiring new knowledge (e.g. looking for possibilities) and using existing knowledge (e.g. product review meetings, benchmarking). Systems thinking and feedback related categories were acquiring feedback (e.g. direct feedback and quality management systems) and actions taken (e.g. handling feedback together with partners), and finally the dynamic capabilities

view was categorized as network development (roles, network capabilities) and future strategy issues (e.g. new possibilities, strategic objectives).

Table 4 Practices for learning on network level

Theoretical viewpoints of learning	Category of practices	Groups of practices related to learning	Examples of short descriptions
Organizational memory	Formal storage	Processes and instructions[1,2,3] Databases and information systems[1,2,3] Documents and standards[1,2,3]	Learning and teaching processes to partners Shared ERP or PDM systems Shared specifications, drawings, industry standards
	Informal storage	Personal memory[1,2] History[2]	Partners in our premises Shared experiences
Absorptive capacity, relative absorptive capacity	Similarity of organizations Differences between organizations	Using known partners[1,3] Objectives[2] Different roles[2] Complementary capabilities[2] Combining different capabilities[3]	Past experiences Similarity for customer Clearly different focus Different specialization areas Learning by combining different partners' expertise
Tacit and explicit knowledge	Events	Meetings with partners[1,2] Trainings together[1,3] Product development sessions[1]	Regular update meetings Product trainings Ideation workshops
	Personal experiences	Experience of doing together[2,3] People moving tacit knowledge[2,3]	Joint projects Delivery inspector
	Formal structures	Strategy and processes[1,2]	Defined way to operate
Exploration and exploitation learning	Acquiring new knowledge Using existing knowledge	Looking for new possibilities[1,2,3] External specialists[3] Co-development[2] Finding existing knowledge in the network[1,2,3]	Industry forums Benchmarking Speaker exchange Shared problem solving Company visits Product review meetings
Systems thinking and feedback	Acquiring feedback	Getting direct feedback from customers, suppliers and others[1,2,3] Product development process feedback[3]	User interviews with partners, project learning feedback Review meetings, iterations Continuous

	Actions taken	Quality management systems[1,3]	statistical information
		Process development[1,3]	Integrating changes, Correcting mistakes
		Operational level problem-solving[2]	Quality feedback
		Handling feedback together with partners[2]	sessions, regular meeting
Dynamic capabilities	Network development	Roles[1]	Knowing expertise of others, changing roles
		Network capabilities development[1,2,3]	Capability objectives, mutual learning
	Future strategy	New possibilities[1,2]	Identification of possibilities
		Competitiveness in the future[1]	Focusing with partners
		Strategic objectives[2,3]	Shared objectives
		Communicating future objectives[3]	Different views of future

The viewpoints of learning that were the most emphasized in the interviews, where a lot of different practices were identified, were organizational memory, tacit and explicit knowledge and explorative and exploitative learning. On the other hand, the interviewees saw that practices related to some other learning views such as absorptive capacity or dynamic capabilities were difficult to identify, and in general, the learning was not systematically supported in the daily operations, especially on the network level.

Examples of practices related to organizational memory on the network level were teaching partners about own processes and partners' (limited) access to information systems such as enterprise resource planning (ERP) or product data management (PDM) systems. More informal storage forms were related to personal level, individual memory and experiences, since the respondents saw that part of the organizational memory is always tied to individuals and the only way to share that is moving people across organizations. In absorptive capacity, the similarity of organizations was seen as necessary because past experiences with partners help especially in situations with completely new products, and the objectives need to be similar at least so that the end customer can see the operation of the network as unified as possible. Differences between organizations were seen important for learning in the sense that different specialization areas and clear roles make it possible to co-operate but simultaneously also learn from the partners.

The respondents saw severe difficulties in sharing tacit knowledge between organizations, especially for several organizations as a network, but practices related to sharing and using tacit and explicit knowledge included events such as shared ideation meetings, update meetings and trainings. On the level of personal experiences, doing joint projects together with partners or moving people around, as explained above, were seen as ways to learn and share particularly tacit knowledge. In network 1 there was a "delivery inspector", who regularly visited suppliers to show them how to make the products according to the company instructions. The companies had several ways to acquire new knowledge (new to the organization) such as participating in industry forums, exchanging expert speakers between partners, and doing benchmarking visits

together. Examples of finding and using existing knowledge in the network included shared problem solving, company visits and product review meetings.

Related to systems thinking and learning based on feedback, the ways of getting and delivering feedback on the network level included user interviews together with partners and shared post-project evaluations of what has been learnt as well as statistical information from quality systems that was shared with partners. The actions that were taken based on feedback were three kinds: immediate problem solving, introducing changes on processes or products. Handling feedback with partners was done by separate quality feedback meetings or regular partner meetings.

Concerning the dynamic capabilities on the network level, the development of roles and capabilities in the network included knowledge about the expertise of others and changes with time, for example a partner may widen it's role based on changes elsewhere in the network. Some objectives of desired capabilities were given to partners, but generally there seemed to be no systematic way of supporting network level capability development, although the respondents saw that development happens with time through mutual learning. The network view of the future was seen to emerge through identification of possibilities together by the network, developing competitiveness through better focus and shared objectives, and communicating the objectives to partners. However, the respondents also said that discussing possible futures only happens with especially important partners, and sometimes the objectives need to be communicated in a different way to different stakeholders in the network.

5 Discussion and conclusions

As the result of this study, we have improved the understanding of the phenomenon of organizational learning in the context of innovation networks in particular. This contributes to the understanding of networked innovation, when regarding the whole network as the learning unit, instead of merely studying organizational learning from the perspective of dyads and individual organizations. This study has brought new understanding of both the challenges as well as possibilities of learning in the context of innovation networks.

The research design makes it possible to relate theoretical concepts to empirical data and thus provide a practical view of network learning especially related to innovation activities. Combining several theoretical viewpoints results into better understanding of the network learning phenomenon, through producing a more holistic and versatile picture than using only one theoretical starting point. A holistic approach resembles the every-day situation in the organizations, where challenges and practices are connected to many things simultaneously.

The paper identified several types of challenging aspects of learning in innovation networks on the levels of organization, dyadic relationship and inter-organizational networks. Main categories of network level challenges were identified as sharing knowledge, competition and general network operation related challenges. Also, some examples of learning-related practices were identified and classified. The categorization of learning challenges on the network level and practices for learning between multiple organizations help to recognize some important issues that managers need to pay attention to, and show possibilities for developing more systematic support for learning also on the network level through several types of practices.

In general, the experienced challenges varied between the networks, and between organizations inside each network on different levels. In network 1, the challenges for learning were mainly focused on internal knowledge management and securing knowhow, whereas in network 2 a special emphasis was on developing partnerships, and in network 3 the issues of intellectual property rights and contracts were frequently mentioned as challenges affecting knowledge sharing and learning between partners. Challenges related to sharing tacit knowledge were seen as very important from innovation activities perspective. There are also several other challenges such as competitors within the same network and the coordination of the network, when considering network-level learning and knowledge generation in the current situation.

Practices related to learning from the point of view of the different theoretical approaches were found in several different forms. The interviewees in the research identified many practices which can help in inter-organizational learning, both on a dyad and network level. The learning phenomenon and supporting it is typically not separately focused on, but rather it is seen as a part of every day activities and processes, if recognized at all. However, the effect of learning on reaching the financial objectives and staying competitive is seen as important on the strategic level.

The results above show that mostly the companies in the networks do not think of the co-operation or especially learning in the co-operation in terms of the whole network, but rather from the point of view of their own organization or from the point of view of a single dyadic relationship between partners. Another interesting question is the responsibility for learning on the network level. The respondents recognized the different roles needed in the network, and the need for a leader of the network, but are not considering themselves as the leaders or coordinators. Also, the networks are seen more as a form of traditional supply chain co-operation, and from the customer side there is an assumption that the partners will be able to develop themselves and learn the necessary things on their own. The level of co-operation varies, but an integrated network approach with common objectives seems to be missing. This is also true in the network which included a non-commercial research partner. The practices of co-operation seem to change slowly, and old routines and thinking patterns continue even if the operation models are changing from the supply chain to a network.

The need for common objectives for learning as well as other areas of co-operation was recognized in this study as one of the key elements in inter-organizational learning in innovation networks. If common objectives are not created together and perceived in a similar way within networks, and network-level learning is not perceived as an important objective, it may be that real networked way of innovation is still in many companies in its early steps. While the competitiveness is not regarded any more to be the result of the independent organizations' activities, but whole networks compete with each other, and the competition is getting harder, companies still possess thinking patterns which are derived from earlier value chain thinking instead of value network thinking. To improve their competitiveness, companies should aim to develop their ways of operation towards more in-depth patterns of collaboration, this including learning and knowledge creation to become a more important focus from the perspective of the whole network. This study can provide managers ideas about the important barriers in network and inter-organizational learning, as well as for ways to regard and improve learning from different perspectives, not only from one or two standpoints. The tables formed in this study based on the categorization of the challenges and learning practices can be used as a basis for the development of their own organizations and networks.

The used content analysis method enabled to analyze the phenomenon moving the viewpoint to the real opinions of the studied interviewees and as a result, probably to get a more realistic and unbiased view of how the companies themselves see learning within the studied networks. This method seemed also suitable for our research approach where we utilized various theoretical standpoints in the interview framework, for aiming to get a more varied picture of the relatively little studied phenomenon of network- level learning.

Selection of case networks and interviewees was based on preliminary information on the companies involved, and on the assumption that since these organizations operate in a network with their partners in innovation activities, the people responsible for R&D or other development activities would have the best knowledge about the research subject based on their every-day experiences and would be able to also point out new interviewees. However, this selection method means that in the interviews certain opinions might be emphasized more than with other kinds of selection methods. In addition to this, the case study approach means that the results based on the cases presented in this study cannot be generalized as such to all other types of networks or industries, but will probably be useful to companies and networks in similar situations.

As some important challenges and supporting factors for inter-organizational and network learning have been identified in this research, it provides a starting point for new analyses, for example the differences between the case networks need further analysing. Future research related to the topic could consist of for example modelling the individual items behind the learning challenges and their effects on the innovation process with system dynamics or other approaches, or continuing with forming a survey based on these more thematic and descriptive results to obtain more insights and detailed information on the network level. One area of further research is to complement the results of this study by studying advanced network organizations with particularly long or in-depth experience from networked innovation, and well-established collaboration and coordination patterns.

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Publication V

Contribution of virtual teams to learning and knowledge generation in innovation-related projects

Eric Stevens*

Groupe ESCEM
1 rue Léo Delibes, BP 0535
37 205 Tours Cedex, France
E-mail: estevens@escem.fr
*Corresponding author

Hannu Kärkkäinen and Hannele Lampela

Department of Industrial Engineering and Management
Lappeenranta University of Technology
P.O. Box 20, 53851 Lappeenranta, Finland
E-mail: hannu.karkkainen@lut.fi
E-mail: hannele.lampela@lut.fi

Abstract: Virtual Teams (VTs), consisting of participants from many geographically distant subunits, or even belonging to many organisations and communicating mainly through ICT, are used for the purpose of sharing development costs and shortening the time to market. The paper analyses how a VT may facilitate or prevent learning, knowledge generation, and ideation processes in New Product/Service Development (NP/SD). First, the definition of VTs as a specific form of organisation is discussed. Then a review of what has been written about this kind of organisation is given, to provide a better understanding of how this organisational form may impact the NP/SD process. Given the fact that few studies have been produced on the topic, the main research areas requiring further investigations are identified. Managerial recommendations are offered as a conclusion.

Hannu Kärkkäinen is a Professor at the Department of Industrial Management at Lappeenranta University of Technology in Finland. Dr. Kärkkäinen received his DSc (Tech) from Lappeenranta University of Technology. His current research interests include the early-phase management of R&D, knowledge management and decision making in innovation, customer needs assessment in business-to-business organisations, and the cooperation and value networks in product innovation. He has published a number of refereed international journal articles in such journals as *International Journal of Technology Management*, *R&D Management* and *International Journal of Production Economics*, as well as books and other publications on the above research topics.

Hannele Lampela holds MSc degrees in Economics and in Technology from Lappeenranta University of Technology, Finland. At the moment she works as an Assistant and a doctoral student at the Department of Industrial Management at Lappeenranta University of Technology, with diverse courses on knowledge management and innovation. She also has previous work experience from software companies in various sales and marketing positions.

1   Introduction

The growing interest in the research of Virtual Teams (VTs) reveals that this form of organisation is becoming commonplace within companies (Gibson and Cohen, 2003). This new form of organisation results from the convergence of ICT technologies, from the growing degree of internationalisation of companies and markets, and eventually from the benefits resulting from this way of organising teams (Solomon, 2001). Overcoming geographic distance, associating a broader range of competencies and reducing costs are, among others, the expected benefits resulting from the adoption of VTs (Martins *et al.*, 2004). The interest in research is further reinforced when it is considered that more and more teams are working virtually, and some degree of virtualness is a component of most teams (Martins *et al.*, 2004).

Effective VTs must be able to produce high-quality outputs (*i.e.*, products and services), reward the team members in terms of gratification and satisfaction with the working experience (Jarvenpaa and Ives, 1994), and contribute to individuals' learning and ability to engage in future projects (see also Powell *et al.*, 2004). According to the literature review of Hertel *et al.* (2005), what is generally needed is research that examines, for instance, how experiences and best practices can be passed on to future VTs, leading to more effective learning concerning individuals as well as the organisations involved. Martins *et al.* (2004) state that, in particular, the implications of virtualness for a team's contribution to an organisation's tacit and explicit knowledge should be studied in future research. Similarly, higher-level cognitive outcomes, such as team creativity and learning, have not been examined extensively and are important areas for the extension of research on VTs. The research on traditional teams and team learning gives a theoretical background for the research of VTs, but owing to the unique challenges in managerial, technical and social aspects of VTs, they need to be considered in specialised research (Powell *et al.*, 2004).

Innovation-related learning is valuable because it leads to further innovation. The firms' learning capabilities play a crucial role in generating innovations (Sinkula *et al.*, 1997). Learning enables organisations to renew themselves and to keep up with

competition; furthermore, learning faster and more effectively than the competitors may be the only source of sustainable competitive advantage in competitive markets (*e.g.*, Slater and Narver, 1995).

VTs represent multiple interests when the development of new products and services is concerned. First, the international extension of companies and markets leads the development teams to address globally distributed consumers. Because of their capacity to integrate new members with experience of local contexts and cultures, VTs are supposed to multiply the chance to provide solutions fitting the expectations. Second, in a fast-moving economy, the competencies required to develop new offers change constantly. Owing to its flexibility, the VT provides, at a very low cost, the possibility to adapt the knowledge and skills required for performing the tasks. Third, cultural diversity is recognised to contribute positively to the creativity of teams (Watson *et al*., 1993; Ling, 1990, quoted in McDonough, 2001; McDonough *et al*., 2001).

Owing to the rather recent interest in such organisational forms, the capacity of VTs to facilitate knowledge generation and learning in the context of New Product/Service Development (NP/SD) has been studied very little. This paper aims at filling this gap. The paper comprises four parts: The first part contains a comprehensive analysis of VTs and the benefits and limits that can be expected in this organisational form. The second part of the paper investigates the learning and knowledge generation in the context of NP/SD. In the third part, the strengths and weaknesses of virtual NP/SD teams in knowledge generation and learning are analysed. Finally, we propose recommendations for the management of VTs and suggest some directions for further research.

2   Virtual teams

Shortening product life cycles, globalisation of the economy, and the requirement of answering customer needs faster than before are examples of the global trends driving organisational change today (Powell *et al*., 2004). VTs are seen as an answer to minimising the time, costs and coordination of the workforce, increasingly dispersed across various locations and maybe even organisations (Martins *et al*., 2004).

There are several simultaneous global trends that make the utilisation and study of VTs very current and interesting. First, the competencies of international companies are increasingly spread out to different geographic locations (Ghosh and Varghese, 2004). Second, the development of highly sophisticated offers requires a broader scope of competencies, which companies are obliged to get through strategic alliances (Gerwin and Ferris, 2004). Third, the diffusion and power of IT tools have reached a state of maturity that makes them practical and useful in global operations. They offer new means for distant communication, facilitating the exchange of all kinds of data and knowledge (Hertel *et al*., 2005; Powell *et al*., 2004).

VTs are used in many different fields, for example in R&D, problem-solving task forces, customer service, and also for noneconomic purposes, such as scientific collaboration (Hertel *et al*., 2005). According to several studies (Kratzer *et al*., 2006; Leenders *et al*., 2003; Drucker, 1988; Boutellier *et al*., 1998), VTs are perhaps most evident in the area of New Product Development (NPD). However, virtual NPD teams within and between organisations can still be seen as a recent phenomenon (Andres, 2002). In this section, we present a general overview of VTs, concentrating first on

the most common definitions and characteristics of this organisational form, and then on the benefits and limitations presented by VTs, and finally on life cycle models of VT development.

2.1   Definitions and characteristics of virtual teams

Each time a team is made up of members who are distributed across various locations, it can be considered a VT. The definition of a VT covers a broad scope of organisations, including informal teams, as well as teams created within strategic alliances. A common definition, also used as the starting point in this paper, is that a VT is a functioning team that relies on technology-mediated communication while crossing several boundaries, such as geographical, time and organisational boundaries (Martins *et al.*, 2004; Chudoba and Wynn, 2005). VTs represent a new form of organisation that offers a great span of flexibility and responsiveness, which makes them interesting for development projects.

Teams differ from other groups by their high interdependency and integration of members, as well as a shared purpose. A team also has shared responsibility for the outcome, and it is seen as a social entity of its own. Thus, a traditional definition of a team as a special kind of a group includes that it is a small number of people with complementary skills, committed to a common purpose, goals and approach with mutual accountability (Katzenbach and Smith, 1993; Levi and Slem, 1995). VTs differ from other teams in that they are dispersed teams that have a shared task, and they are not limited by the boundaries of organisation, geography and/or time. A distinctive feature is the VT's reliance on IT in communication, which can be either exclusive or used predominantly to support other actions (Powell *et al.*, 2004). The core of the definition of VTs seems to be its reliance on technologies to cross different boundaries. The most common boundaries are geography (teams can be located all over the world), time (different time zones, asynchronous communication) and organisation (members from several different organisations). Other additional features of VTs mentioned by some researchers are the possibly more fluid membership of the team and a shorter life cycle than in other kinds of teams (Martins *et al*, 2004).

In recent years, as the research has multiplied, several very similar definitions of VTs have been presented. These definitions overlap at the core and have small variations in the specifics. The trend in the definitions is shifting away from defining VTs as a specific type of team as opposed to 'traditional teams', and focusing instead on 'virtualness' as a potential characteristic of all teams. Earlier studies on VTs have mainly concentrated on comparisons between virtual and traditional teams (Powell *et al*., 2004), finding contrasts and similarities in the organisation and management. They have paid attention especially to the geographic dispersion and the technology-based interaction of VTs (Martins *et al*., 2004).

Recent definitions have focused on the extent of the virtualness of a team, which may vary depending on the nature of the task, technological resources, and members' skills and capabilities (*e.g.*, Bell and Kozlowski, 2002; Griffith and Neale, 2001; Kirkman *et al*., 2004; Zigurs, 2003). In addition to the earlier focus, the definition now takes into account the degree of technology mediation, allowing for some face-to-face communication, since a purely face-to-face team that does not use any communication technology is rare (Martins *et al*., 2004). Thus, the definition of VTs treats virtualness as a team characteristic, similar to other attributes. The degree of virtualness is focused on, rather than division between traditional teams and VTs.

The number of persons and the degree of interaction are also important characteristics for defining VTs, since they include many forms of virtual work. Hertel *et al*. (2005) state that a specific definition of a VT is still under controversy, but a consensus has been found that a VT must (1) have at least two persons working and interacting to achieve a common goal, so that (2) they are separated by location, organisation or time and thus need to (3) communicate and coordinate the work through electronic communication media.

When concentrating on R&D and NPD, there are several ways of classifying teams. One classification provided by McDonough *et al*. (2001) distinguishes between collocated, virtual and global NPD teams, where virtual NPD teams comprise any individuals who have a moderate level of physical proximity and are culturally similar. This includes people working within the same country but in different locations, or when the team members are in the same location but do not have direct contact, for example if they are located on different floors of the building (McDonough *et al*., 2001). Other studies (*e.g.*, Leenders *et al*., 2003; Kratzer *et al*., 2006) combine the virtual and global teams presented by McDonough *et al*., and use virtual NPD teams to refer to any development team in which the members are working separated by distance, time and other constraints.

2.2 *Benefits and limitations of virtual teams*

According to Martins *et al*. (2004), researchers have sought to understand the benefits and costs related to VTs for the last decade.

One general kind of benefit with VTs is that they enable the aggregation of best individuals for a task, regardless of their physical or organisational location, which enhances the quality of decisions (*e.g.*, Lipnack and Stamps, 1999). In addition, VTs provide a mechanism for handling the increased travel, time, coordination and costs associated with bringing together geographically, temporally and functionally dispersed employees to work on a common task (Martins *et al*., 2004), such as the development of new products and/or services.

According to Martins *et al*. (2004), the benefits and challenges of VTs are strongly related to the various processes of VTs, such as planning or goal setting, action or decision processes, and interpersonal processes (enabling, for instance, trust among the team members), as well as many variables concerning the design and compositional characteristics of a team, such as knowledge and skills of the VT participants, group size, mediating technologies and their media richness,[1] group composition and task type. The effect of these processes and variables can, however, be a complex one: for instance, it has been noted that when the task of a team is ambiguous, the extent of virtualness may increase the length of time needed to reach the shared goal, but at the same time, it may also actually assist in the development of a more focused or better goal (Straus and McGrath, 1994).

For a product, service or other development effort involving multiple organisations, organising virtually has the potential to greatly reduce costs: personnel disruption, travel and other relocation costs would all be significantly reduced, with favourable implications for resource commitments, time to market, and product-introduction frequency (O'Sullivan, 2003). Organising virtually would also make a worldwide pool of potential partners available, thereby giving access to a wider range of

competencies than otherwise, and perhaps also more flexibility in the terms under which the development risks are shared (Snow *et al.*, 1996). The extensive use of distributed information technologies can provide broad and rapid access to many other project participants, an important consideration when the number of personnel is in the thousands, which is not uncommon in complex development projects (*e.g.*, Sabbagh, 1995).

The organising of work virtually can create many benefits, in addition to giving a wider access to various competencies. Along with the increase in diversity in organisational and geographical cultures, it seems that multicultural teams also have higher levels of creativity (Ling, 1990, quoted in McDonough, 2001) and they develop more and better alternative solutions to a problem (*e.g.*, Watson *et al.*, 1993) than teams with less cultural diversity.

However, in a work context (such as new product and service development) that encompasses many boundaries – cross-functional, cross-team, cross-organisational, and, increasingly more often, also cross-geographical and cross-cultural – endemic misinterpretations and conflicts are probable, resulting from incompatibility between communication norms and practices formed in different organisational contexts (Jarvenpaa and Leidner, 1998, quoted in McDonough, 2001; Malhotra *et al.*, 2001; O'Sullivan, 2003). This raises many challenges concerning efficient knowledge generation, learning and creativity to be dealt with in VTs, especially multinational or global VTs.

It is admitted that VTs suffer from many weaknesses, such as a low conflict-resolution capacity, a low level of trust, a difficulty to create cohesiveness, and thus difficulty to create shared values and mental models (Furst *et al.*, 2004; von Zedtwitz *et al.*, 2004), due for instance to the achieved media and information richness, as well as the commonly created operative manners and procedures of the team. These limits should be considered potential sources of failure for new product or service development. With limited trust and weak cohesiveness, the firms' learning capabilities, which play a crucial role in generating innovations (Sinkula *et al.*, 1997), may be questioned.

An important issue in the context of virtual teamwork is the management of knowledge and the development of shared understanding within the teams (Olson and Olson, 2001). The development of such a common ground can become especially challenging in VTs, owing to the sharing of information and the development of a 'transactive memory' (*i.e.*, who knows what in the team) becoming more difficult; for instance, because of the reduced amount of face-to-face communication and reduced information about individual work contexts (Hertel *et al.*, 2005; Griffith and Neale, 2001). However, while the development of a shared understanding of team goals and tasks might be more difficult in VTs because of the reduced synchronous communication, this same process may also lead to less biased use of shared information owing to a higher degree of asynchronous processing and greater psychological safety, or to a lower group pressure in VTs (Griffith and Neale, 2001).

2.3 Life cycle model of virtual teams

A life cycle model of VT management has been presented, for example by Hertel *et al.* (2005). This model concentrates on the human resource issues that need special attention because of the high degree of virtuality. The phases of the life cycle are preparation, launch, performance management, team development and disbanding. A similar approach

to life cycle and team development can be found from Büchel and Raub (2002), who write about knowledge-creating value networks. They define the stages of network development and the focal issues in each stage of development as follows: the first stage is focusing the network, the second is creating the working context, the third routinising the activities, and the fourth leveraging the results.

Boutellier *et al*. (1998) have studied the use of IT tools in different stages of dispersed R&D projects, and the general stages they present are planning, design, implementation and testing. The purposes for using IT are different at each stage, depending on what kind of knowledge is processed and whether the processing takes place on a rational or emotional level. There are four basic tasks in which IT can support dispersed R&D: coordination of project activities; information exchange; promoting creativity and development of informal networks; and trust. By combining this with the life cycle model presented, we can say that in the early stages of the life cycle of a team, the emotional-level tasks of promoting creativity and developing networks are more at focus, and in later phases the rational-level tasks of coordination and information exchange have a bigger role. The dynamics and changing needs during the life cycle are presented in Figure 1.

Furst *et al*. (2004) have used the team life cycle model developed by Tuckman (1965) to describe the stages of virtual project team development and the challenges that virtuality raises. Their model comprises four phases: forming, storming, norming and performing. In the forming phase, the team members get to know each other and share both explicit and tacit knowledge. The aim is to establish trust and share goals and expectations. This might lead to different opinions that need to be resolved in the storming stage. Groups then move into the norming stage, where the team agrees on common working rules and procedures to achieve better understanding and coordination. In the performing stage, the team members work together towards a shared goal, helping and encouraging each other.

Figure 1 Dynamics and need for IT support in different phases of development projects
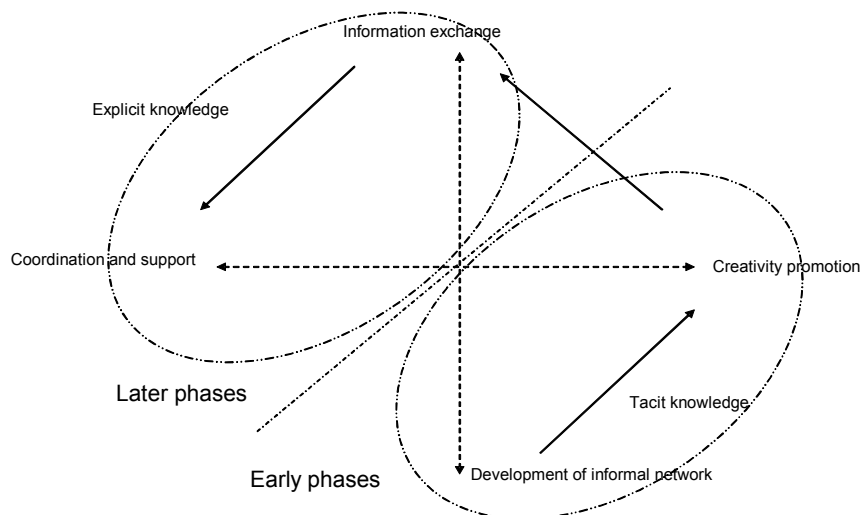
Source: Boutellier *et al*. (1998)

To have a better picture of the life cycle of a VT from the learning perspective, we will modify the models by combining the later phases of team development and disbanding from Hertel *et al*. (2005) with the basic model of VT development by Furst *et al*. (2004), and integrating some earlier phases together. As the result we present a model of five stages:

1   preparation/forming

2   launch

3   norming

4   performing and team development

5   finishing/disbanding.

Each stage is presented in more detail in Figure 2.

In this model, the preparation phase has been combined with forming, as both are the starting phases for the working of a VT. The launch phase is presented separately, since it has a significant impact on successful learning results in the VT, for example by creating mutual knowledge and fostering trust. The norming stage in this model comprises the storming and norming stages of Furst *et al*. (2004), since the storming stage has not been seen as a major stage in VTs, but rather as a part of defining the common rules and team practices in norming. The performing stage has been combined with team development, since the former is the actual productive working phase of the VT, and the team development must be concurrent with this. Finally, the finishing or disbanding stage from Hertel *et al*. (2005) has been added to the model because, for learning, the last phases and ensuring the sharing of knowledge in the ending phase are of crucial importance. In each of the presented models, the high degree of virtuality sets its own requirements on how to produce innovation results successfully, and the characteristics of the tools and processes that are used also affect the results.

Figure 2   A five-stage model of the life cycle of a virtual team

Stage 1 Preparation/ Forming	Stage 2 Launch	Stage 3 Norming	Stage 4 Performing and team development	Stage 5 Finishing/ Disbanding
- Gettting to know each other - Ensuring management support - Creating links - Establishing trust	- Establishing mutual knowledge - Goal clarification - Choosing appropriate communication mechanisms - Fostering trust	- Defining team rules - Choosing working practices and tools - Regulation of communication	- Team members working together towards shared goals - Motivating leadership - Individual/team training according to skills deficits	- Recognition of achievements - Sharing learning experiences - Re-integration of team members

Sources: Modified from Furst *et al*. (2004), Hertel *et al*. (2005), and Büchel and Raub (2002)

3 Learning and knowledge generation processes in NP/SD virtual teams

In this section, we focus first on the fact that one of the key issues in NP/SD is the creation of new knowledge. Then we detail the process by which new knowledge may be created. This leads us to analyse the factors that can support or prevent knowledge creation processes. Last, we discuss the ways by which the specificities of VTs may support or prevent learning while innovating.

3.1 NP/SD as knowledge creation process

The research of the last 20 years has arrived at a broad consensus in establishing a link between NP/SD and knowledge creation. When the firm is considered able to operate owing to its competencies (Hamel and Prahalad, 1994), the capability to perform a task relies on a set of routines, shared understanding, procedures, internal communication systems and practices that support and guide the action of each of the organisation's members. In other words, experiences of day-to-day activities are captured in the organisational routines of the firm (Nelson and Winter, 1982) and result in adjusted collective behaviour. Changing the output of the company – innovating – requires by consequence creating new knowledge from which ensues the capacity to produce new outcomes.

The knowledge base of the organisation is embedded in social processes (Kogut and Zander, 1992). As organisations are made up of individuals who bring their own repertories of skills, competencies and experiences, organisational cognition emerges from the interaction of these individuals and results in the cognitive performance of the group. Knowledge creation ensues from the exchange and combination of previously unconnected pieces of knowledge (Murray and Worren, 2001). This leads to considering that the architecture of the organisation may determine the potential for creating new knowledge (Kay, 1993). A VT, as one possible architectural option, may thus influence the content, speed and relevancy of the knowledge generation process.

3.2 Knowledge generation processes in NP/SD

Knowledge generation has been considered from different perspectives, according to the emphasis put on the tacit or explicit content of knowledge, or to the individual or organisational dimension of learning. One perspective on organisational learning has been presented by Crossan *et al*. (1999). Their model is called the 4I-model according to the terms used in it. The model is based on four basic assumptions:

1 In organisational learning there is a tension between using existing knowledge and creating new knowledge.

2 Organisational learning occurs between an individual, a group and the organisation.

3 Social and psychological processes are closely linked to organisational learning.

4 The schemes that people have guide their actions and vice versa – the actions modify the schemes.

In other words, when at the individual level, learning is achieved mainly through experiences and discussions; interaction and shared visions have to be considered at the group cognition level. Eventually, at the organisational level, the important elements of learning are in processes, routines and rules. When the results of team learning are transferred at the organisational level into processes and systems supporting them, this is called institutional competence (Crossan *et al.*, 1999; compare also De Geus, 1998).

Learning may be considered to be derived from the accumulation of experience. In reaction to the experiences encountered, individuals will gather data, process them and eventually improve the existing processes. Typically, gathering existing data, measuring, observation of the competition, prototyping and testing will be the kind of action an NP/SD may implement in order to realise single-loop learning (Argyris and Schon, 1996).

However, at the heart of the knowledge generation process there is the distinction between tacit and explicit knowledge. By asserting that "we know more than we can tell", Polanyi (1966) points out that part of individual knowledge is made up of subjective insights, intuitions and life experiences, which are not articulated into formal and explicit knowledge that is easy to share and transfer. Far from processing information as a computer would do, creating knowledge depends on tapping the tacit individual skills and on making them explicit and thus available to the other parts of the organisation (Nonaka, 1994).

This process is achieved through social interaction. Observation of others' behaviour, the use of metaphors, analogies, hypotheses or models are the different means used to make individual knowledge explicit (Nonaka and Takeuchi, 1995). In this perspective, the socialisation process – the flow of formal and informal interaction it will occur in – is at the core of learning (Stevens and Dimitriadis, 2004). Producing and discussing hypotheses about consumers, using guiding visions, opening internal and external debates, checking the convergence of the interpretations, implementing different problem-solving heuristics (Anderson, 1995) are among other means through which the NPD teams progressively create and design innovative solutions through a double learning loop (Argyris and Schon, 1996).

Eventually, in order to be able to perform the innovations and to survive the staff turnover, organisations have to institutionalise the knowledge created. During this stage, individual and group knowledge becomes embedded in the organisation: "Over time, spontaneous individual and group learning become less prevalent, as prior learning becomes embedded in the organization and begins to guide actions and learning of organizational members" (Crossan *et al.*, 1999). The institutionalising process is achieved through the implementation of a coordinated set of actions, procedures and routines, which are internalised by the individuals (Nonaka and Takeuchi, 1995). As stated above, innovation is a process by which the knowledge embedded in the NP/SD team is embodied in the product (Madhavan and Grover, 1998). The routinisation of the results producing expected consequences will transform the collective exploration into an adapted body of rules, routines and procedures. In this part, the creation of a new department, adaptation of job descriptions, reengineering of processes, organisation of training sessions, freezing of the specifications of the products, and memorisation of sequences of processes are the means through which learning is transformed into an outcome.

The knowledge generation process in innovating is summarised in Table 1, inspired by Crossan *et al*. (1999). The table displays the level at which the knowledge generation is produced, the processes that are underway, the outcomes and some examples of the learning actions that may be implemented.

Table 1 Learning in organisations: four processes at three levels

Level	Process	Inputs/Outcomes	Learning actions
Individual	Intuiting	Experiences	Observation of others
		Images	Experiments and behaviours.
		Metaphors	Producing new interpretations
Group	Interpreting	Language	Building new representations.
		Cognitive maps	Building hypotheses and conjectures
		Conversation/Dialogues	
Organisation	Integrating	Shared understandings	Testing the convergence of the interpretations, trial and error. Simulation. Formal and/or informal discussions. Building hypotheses and conjectures. Transfer of the previous personal experience to the development group. Acquisition of information
		Mutual adjustment	
		Interactive systems	
	Institutionalising	Routines	Creation of new department. Change in job descriptions. Process reengineering. Training sessions. Freezing the product specifications. Memorisation of sequences of processes
		Diagnostic systems	
		Rules and procedures	

Source: Modified from Crossan *et al*. (1999)

Having analysed the processes by which firms can learn for the purpose of creating new offerings, it is clear that the kind of organisation in charge of the development may influence the final outcome. In other words, virtual organisations do not contribute to learning in the same way as collocated teams do. In the next section, we review the ways that VTs may contribute to the learning processes.

4 Virtual teams and NP/SD

The growing trend of moving towards VTs is evident in NPD, because the task of creating new products or services has become more complex and information-rich. The needed skills are possessed by several individuals, possibly around the world, and firms need to adjust their operations to access the required knowledge. Internationalisation, specialisation of skills and the requirement of including different kinds of knowledge in the development process are all factors that increase the need to use VTs in NPD (Leenders *et al*., 2003). Firms need to disperse their development units to access all required knowledge and skills. This results in a general movement towards more virtual R&D teams (Kratzer *et al*., 2006).

From the standpoint of knowledge creation and learning in organisations, the innovation and product or service development activities and processes are particularly challenging, because, for instance, they include a relatively large number of agents and process steps interacting with each other. This leads to increased coordination complexity, tight interdependencies between various agents and process steps, long development cycles before the results of decisions and actions can be observed and feedback received, long physical distance from actions to their effects, and missing or misperceived feedback from decisions and actions (see, *e.g.*, Eppler *et al.*, 1999; Holmberg, 2000; Rigby *et al.*, 2000). Also, the related development processes are quite complex and often include a vast amount of contingencies, thus increasing the challenge.

The issues of knowledge management have not yet been very widely studied within virtual NPD research, and Cooper (2003) states that despite the efforts of studying the technology used by VTs to support their actions, there is a lack of research on how to provide the distributed team members with the knowledge they need, especially from sources outside the team. From a close analysis of the learning processes, it is possible to provide an initial list of the potential benefits and limits of the use of VT for NP/SD. This analysis is summarised in Table 1 in the Appendix.

4.1   Positive support for learning in NP/SD virtual teams

The main benefits of using VT for innovation are linked to the capacity to improve the portfolio of competencies associated with the product, increase creativity, establish closer proximities to local markets, and eventually limit the development costs.

The interest in extending the competence portfolio was identified very early in the research on innovation. The work of Katz and Tushman (1981, quoted in Brown and Eisenhardt, 1995) and Ancona and Caldwell (1990; 1992) demonstrated that while operating, successful teams made better use of external networks which provided support for finding access to solutions. Similarly, Brown and Duguid (1991), by putting the emphasis on the communities of practices, revealed that an extended competence range may increase the individual capacity to contribute to business functions. By reducing the costs and the time and distance limits within which expertise may be gathered, it is possible to increase the effectiveness of the solutions. This effect may be particularly significant when the purpose of the development is to bring international offerings that must fit with multiple cultural and local contexts. A dispersed team made up of people belonging to different countries and cultures can reinforce the understanding of desirable local solutions. Similarly, in networked economies where marketing, R&D, production and assembly lines are remote, the contribution of multiple participants through a virtual network is likely to improve the designed solutions by integrating the local constraints and opportunities.

Cultural diversity may also increase the creative capacity of a group. As it is known that individuals usually suffer from many biases when a decision has to be made, it has been asserted that an organisation may strengthen creativity by implementing specific systems, procedures and processes (Amabile, 1988). Leading the quantitative analysis of innovative firms, Bharadwaj and Menon (2000) confirmed that creativity has to be considered to be the result of the adoption of appropriate organisational mechanisms. As cultural diversity is likely to diversify the scope of individual experiences, it has been identified as one of the efficient means for increasing creativity (McDonough *et al.*,

2001). Thus, it can be concluded that the use of multicultural VTs may be used to increase ideation and the capacity of an organisation to produce divergent solutions during the development.

As VTs provide new possibilities for increasing the scope of associated competencies and individual experiences while reducing the costs, they also contribute to extending the range of potential solutions to existing problems and the capacity to invent new solutions to identified opportunities and problems. For the learning processes, all the operations related to the individual level (see Table 1) may be improved by enlarging the scope of experiences, images and available cognitive maps. New representations and hypothesis-building processes may be enriched by this diversity, resulting in an enriched vision of opportunities and better problem-solving heuristics. However, these benefits will be achieved only when the team is able to overcome the limits inherent in the functioning of this kind of team.

4.2 Challenges for learning in NP/SD virtual teams

Compared with other kinds of organisations, VTs may have many weaknesses. First, communication flows may be considered to be lower than in collocated teams, because of distance. As it is asserted that distance reduces social similarities and shared values (Latane *et al.*, 1995, quoted in McDonough *et al*, 2001), it may be concluded that the capacity to understand each other is lower owing to the degree of virtualness. Specifically, when hypotheses and conjectures are raised through informal conversations, which allow making individual knowledge explicit, an intensive communication flow made up of formal and informal discussions should be necessary for getting results. As observed in different contexts, heedful interrelation has to be achieved in order to design some kind of a collective mind (Weick and Roberts, 1993). As far as learning while innovating is concerned, the group level (see Table 1) is likely to be very sensitive to this issue.

Second, the generation of knowledge has to use and combine individual knowledge. Even in a supportive environment, this process is considered demanding owing to the tacitness of knowledge (Polanyi, 1966) or when it is embedded into ways of living or cultural artefacts such as rites and ceremonies (Czarniawska, 2001). This process is usually achieved by socialisation (Nonaka, 1994). Given the more limited potential of communication provided by information technologies, the capacity to turn tacit know-how into a set of transferable knowledge may appear more difficult than in traditional teams. This may prevent the VT from generating new knowledge out of the knowledge dispersed among the team members of the VT.

Two consequences ensue from the inherent limits presented above. First, even though an extended scope of competencies may be associated with the team, the capacity to use them by transferring the tacit knowledge may be limited. A potential threat for learning while innovating is therefore being able to gather all the competencies required, but remaining unable to use them in a way that can benefit the project. The second consequence is the limited capacity to solve problems and conflicts that may arise during the course of innovation. As the team has to take options and make choices, multiple divergences may occur. The team may diverge on the solutions that have to be adopted. It can diverge in the means that should be used for getting solutions. Conflicts may also arise when the individual objectives are diverging owing to the

different backgrounds of the participants. Finding solutions to complex conflicts in a context of limited communication has to be considered a major limit for the learning capacity in virtual organisations.

The third challenge concerning learning in product or service development is the fact that, regardless of whether the development is carried out virtually or not, NP/SD is quite often carried out in projects. Projects pose special challenges to learning, which means that much of the new knowledge and learning generated during the project are partly discarded and forgotten after the project has been finalised, and the project members have left the project team and have been dispersed in the involved organisation(s). For the latest stages of the development process (see Table 1), which consist of the transformation of the knowledge created into organisational features, the VT organisation may have major weaknesses, as such a team is not in charge of the organisational change induced. This could be a very sensitive area when the created offering contains a significant amount of tacit knowledge, difficult to transfer to the rest of the organisation. Moreover, if the specific project knowledge of the team members is not directly needed after the project, 'organisational amnesia' begins (*e.g.*, Schindler and Eppler, 2003).

5   Conclusions and recommendations for further research and managers

In this research, VTs were compared to traditional teams in product and service development. First, literature concerning VTs was reviewed in order to identify the most common VT characteristics, as well as their common benefits and limitations. Several models of VT life cycles developed for various purposes were combined to form a more generic life cycle model to analyse VT-related learning issues in the different phases of virtual NP/SD. The results are presented in Table 1 in the Appendix. Close analysis of the advantages and limits of the VT in developing new product and service offerings led to identifying main research areas and providing managerial recommendations.

The careful examination of the functioning of the VT highlighted that the adoption and learning of new knowledge by individuals, teams and organisations can be significantly affected by the use of VTs. Thus, VTs can be important tools for facilitated NP/SD-related learning on both single- and double-loop learning levels, when properly used. Our general proposition based on this study is that learning and knowledge generation aspects should be carefully taken into consideration when planning VTs and during their execution, in order to promote not only individual-level but also efficient organisational-level learning and knowledge cumulation to enable learning-based sustainable competitive advantage. Properly designed and utilised, VTs can become important tools for organisations' competitive advantage by shortening lead times and time to market, as well as shortening and facilitating organisations' NP/SD-related learning curves. However, due to their many restrictions, they can also significantly hinder knowledge generation and learning, as well as lead to NP/SD failure.

The number, type and variety of communication means affect the learning and knowledge creation capabilities in VTs. The communication frequency and information richness of the media, in particular, are factors that have a significant effect. In addition, different types of ICT tools should be used in different phases of NP/SD for efficient learning. Generally, the early phases of NP/SD concerning product and concept planning

involve large amounts of tacit knowledge and tacit knowledge exchange, and they can be expected to be significantly more challenging from the standpoint of knowledge generation and learning. More importantly, the early phases of distributed NP/SD by VTs require a carefully designed selection of different types of IT tools to support efficient knowledge generation, learning and creativity, compared to the later phases involving relatively greater exchange of explicit knowledge.

As a major managerial recommendation, specific management of VTs has to be implemented by taking into account their inherent benefits and limits for organisational learning. This can be enhanced, *e.g.*, by proper team leader or project leader training concerning the issues of general importance, the challenges and the possibilities (see Table 1 in the Appendix) of learning, as well as the possibilities of the proper use of ICT tools in the different life cycle phases of VTs to overcome the challenges. To ensure proper knowledge generation and learning results, managers and VT leaders should pay particular attention to the preparation/launch and finishing/disbanding phases, which probably have the most significant influence on effective learning. The essential tasks here are the careful selection of team members according to their respective complementary competencies and experience so that the sufficient diversity needed for creativity and problem solving is ensured; the organisation of specific sessions such as informal, regular meetings or internet chat sessions with all the participants for the purpose of facilitating communication and social processes; the definition of internal rules designed for the purpose of supporting heedful interrelations and learning (priority given to team members' communication, limiting the effect of hierarchy in communication, supporting informal communication through different technological tools, formalisation efforts for sharing knowledge), and the training of participants on the benefits and limits of communication tools for sharing and generating knowledge.

During the performing phases, special attention has to be paid to the potential conflicts that may occur between the participants. Problem-solving stages may be poorly performed owing to asynchronous interaction. Personal conflicts due to divergence on potential solutions may easily occur all throughout the development process. Finding ways to solve such internal conflicts should be considered seriously as a condition of success for the development process.

In addition, the finishing or disbanding phase of the VT is crucial for learning to review the most important learning experiences from the VT members before disbanding the team, as well as making a plan for the storing and distribution of the most important aspects learned. Since all learning issues cannot be similarly important, managers should, for instance, ensure that the focus of the learning aspects is carefully linked to the core competencies of the organisation, in order for the organisational-level learning to be useful and efficient from the standpoint of the company in question. This is important for the success of future VT innovation projects, as well as the long-term competitiveness of the organisation.

With regard to research, it was demonstrated that communication is related to satisfactory NP/SD projects. However, further research is needed to observe:

- the way development teams are created and organised (formally, informally)

- the management of such teams, specifically when cognitive or personal conflicts occur

- the tactics used for transferring the knowledge created by the VT to the rest of the organisation

- individual communication means for making tacit and complex knowledge explicit.

Broadly speaking, those different questions have to be considered as part of a broader research project focusing on the role and dynamics of VTs as sources of organisations' strategic renewability and enablers of efficient organisational learning.

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Note

1　Concerning the definition of the concept of media richness and information richness of different communication technologies, it is clear that various communication media utilised by VTs differ in the richness of the information processed. The determinants of information richness or media richness are the capacity of the medium for immediate feedback, the number of cues and senses involved, personalisation and language variety (Daft and Lengel, 1986). The more a medium incorporates these characteristics, the richer it is. It is apparent that face-to-face is considered the richest medium, because it allows rapid mutual feedback, permits the simultaneous communication of multiple cues (*e.g.*, body language or facial expressions and the tone of voice), uses high-variety natural language and conveys emotion (Suh, 1999).

Appendix

Table 1   Benefits and limitations of virtual team's learning classified by life cycle stages

	1. Preparation	*2. Launch*	*3. Norming*	*4. Performing and team development*	*5. Finishing*
Limitations and restrictions of VTs for learning in NP/SD	Lacking and slower trust development owing to distance, diminished communication frequency and insufficient media richness	Limitations in sharing earlier NP/SD experiences, involving tacit knowledge	Conflicts reducing trust and limiting information exchange in general	Limited utilisation of the creativity potential of group members due to a too small range or unsuitable ICT tools for exchanging tacit knowledge, particularly in the early phases of the NP/SD process	Limited possibility for face-to-face meetings to share experiences and learning results involving tacit knowledge
	Faulty first impressions and person stereotypes, leading to difficulties in creating shared cognitive maps, mental models and commonly understood goals	Misunderstandings, *e.g.*, difficulties in understanding the metaphors used in different cultures	ICT/Communication technology selection limiting the possibilities for information exchange and learning	Lack of informal meetings for continuous sharing of team-learning experiences	Cultural differences might affect the readiness to talk about problems and improvement opportunities during and after the project, reducing the possibility to improve through learning from experience
	Challenge of properly recognising, defining and trusting the expertise of team members (*i.e.*, who knows what)	Creating and explaining ideas about particularly novel types of products and services due to cultural or cognitive barriers	Creation of norms for using, *e.g.*, a suitable set of ICT in virtual teams, or the different phases of their life cycle	Language (or accent) differences and biases, leading to misunderstandings	
		Limited understanding of participants' mental models and cognitions (who is the customer; essential product or project terminology)	Implementing and learning new tools and processes is time-consuming	Maintaining a synergy and information flow between members is challenging (other assignments, free-riding, communication problems, motivation)	
		Too large cognitive barriers limiting information exchange and learning (NP/SD-related cross-functionality and various cultural differences)	Challenge in unlearning the earlier experiences from face-to-face development projects	Finding solutions to complex conflicts is challenging owing to limited communication, which affects the learning capacity	
			Ensuring common understanding of ideas (for instance, in checking the convergence of the interpretations about NP/SD ideas and concepts), *e.g.*, due to different use of language in different cultures		

Table 1   Benefits and limitations of virtual team's learning classified by life cycle stages (continued)

	1. Preparation	2. Launch	3. Norming	4. Performing and team development	5. Finishing
Benefits and opportunities of VTs for learning in NP/SD	Possibility to gather a group consisting of the best available expertise and knowledge for NP/SD

Possibility to gather a group consisting of relatively heterogeneous cultural backgrounds as well as personality types for increased creativity and novel NP/SD solutions | Possibility for fast reactions to changed customer needs, enabling fast project launch by assembling the needed resources quickly

Easier (and simultaneously, limited) conflict recognition/resolution in the early project phases through anonymous electronic means, higher degree of asynchronous processing and greater psychological safety, when necessary | Varied organisational backgrounds and experience base, as well as added creativity owing to cultural variety, for sharing and defining new working processes for NP/SD, as well as selecting new technologies to support them

Reinforcing understanding and learning about local solutions, local customer needs and restrictions/opportunities owing to participants from various countries and/or national locations

Large cultural and cognitive differences may also help to question project goals, NP/SD concept requirements or customer needs held as too self-evident, potentially leading to better results and double-loop learning | Added creativity for product concept and architecture development

Possibility for more regular and frequent interteam communication and feedback, as well as the gathering of learning experiences, enhancing the chance for team learning and knowledge creation

Possibility to utilise ICT tools for team training

Possibility for reacting fast to changed, customer needs, reducing lead-times and time to market

Changes that need the attention of several participants can be communicated fast

Potential to enlarge the scope of experiences and cognitive maps, resulting in enriched vision of NP/SD opportunities | Possibility for arranging learning-related review meetings at the end of NP/SD project faster, diminishing the effect of 'after-project amnesia'

For some people and cultures it is easier to share thoughts and experiences and to give feedback through electronic media without too much personalisation |

Publication VI

Effect of Virtual Teams for Learning in Innovation: Contributing and Inhibiting Factors

Hannele Lampela[1], Hannu Kärkkäinen[1], Eric Stevens[2]
[1]Lappeenranta University of Technology, Department of Industrial Management, P.o. Box 20, 53851 Lappeenranta, Finland
[2]ESCEM School of Business and Management,1 rue Léo Delibes, BP 0535, 37205 Tours, France
hannele.lampela@lut.fi
hannu.karkkainen@lut.fi
estevens@escem.fr

Abstract: The importance of virtual teams is increasing in different areas of business operations as they provide a mechanism for the handling of increased travel, time, coordination, and costs associated with bringing together geographically, temporally and functionally dispersed employees. Due to the relative scarcity of existing research, the objective of the paper is to investigate how the adoption of virtual teams offers benefits and sets challenges for learning in the innovation context. A detailed literature overview summarizes important challenges and benefits of virtual teams for learning. These findings are then reflected with the findings from the empirical part of the study, which have been collected through qualitative methods in two leading-edge companies operating in different sectors located in Finland and France. The managerial implications show which issues virtual team leaders and participants should particularly focus on when facilitating learning and knowledge generation in the context of innovation. From the academic perspective, the results of this study can be used to better understand the critical sources of virtual teams' effectiveness from the standpoint of learning, especially in the context of innovation activities.

Keywords: virtual teams, learning, innovation, learning barriers

1. Introduction

In new product and service development, organizing virtually has favorable implications for resource commitment, time to market, and product-introduction frequency (O'Sullivan, 2003). Furthermore, organizing virtually gives access to a wider range of competences and offers more flexibility in the terms under which development risks are shared (Snow et al., 1996). Along with the increase in diversity in organizational and geographical cultures, it seems that multicultural teams also have higher levels of creativity (Ling, 1990) making them able to develop more and better alternatives to a problem (e.g. Watson et al., 1993).

At a general level, virtual teams have been widely academically studied. However, research concerning virtual teams especially in the context of new product and service development has been very scarce and requires further research. According to Hertel et al. (2005), what generally is needed is research that examines for instance how experiences and best practices can be passed on to future virtual teams, leading to more effective learning concerning individuals as well as organizations. In addition, Martins et al. (2004) state that in particular the implications of virtuality for a team's contribution to an organization's tacit and explicit knowledge should be studied in future research.

The objective of the paper is to study how the adoption of virtual teams offers benefits and challenges for learning in innovation context. Moreover, it covers how both opportunities and challenges are perceived and ranked in practice by virtual team managers and members. The aim is to find the important contributing and inhibiting factors as well as provide explanations for their significance. The paper is organized as follows: in the next sections, the first part will summarize the previous contributions, with a focus on the links established between virtual team life-cycle and learning processes. Then the methodology used for gathering and proceeding data is explained. Then main observations are pointed out and discussed both from the theoretical and managerial perspectives.

2. Theoretical starting points

2.1 Learning during the virtual team life-cycle

There are several studies on team development, and models of team life-cycle stages. In a recent study (Stevens et al., 2006), prior existing models (e.g. Furst et al., 2004; Hertel et al., 2005; Büchel and Raub, 2002) have been used to create a 5-stage model of virtual team life-cycle stages (see Figure 1). The model was formed by combining and integrating the most important phases of virtual teams' life-cycle from the perspective of learning in particular. Later the model has been compared

with recent literature and found to comply with also the recent models used for example in Greenberg et al. (2007).
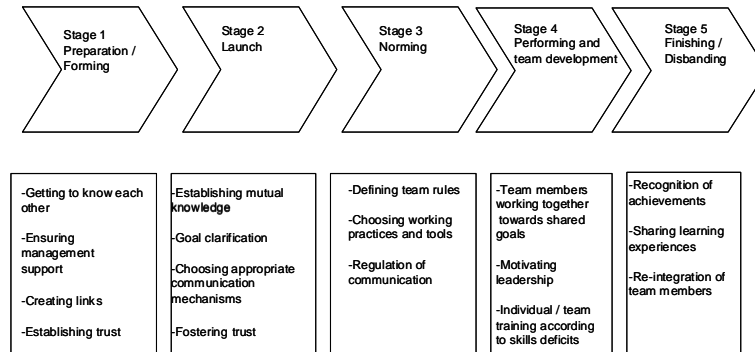

Stage 1 Preparation / Forming	Stage 2 Launch	Stage 3 Norming	Stage 4 Performing and team development	Stage 5 Finishing / Disbanding
-Getting to know each other -Ensuring management support -Creating links -Establishing trust	-Establishing mutual knowledge -Goal clarification -Choosing appropriate communication mechanisms -Fostering trust	-Defining team rules -Choosing working practices and tools -Regulation of communication	-Team members working together towards shared goals -Motivating leadership -Individual / team training according to skills deficits	-Recognition of achievements -Sharing learning experiences -Re-integration of team members

Figure 1. A five-stage model of virtual team life-cycle (Stevens et al., 2006, based on Furst et al., 2004; Hertel et al., 2005; Büchel and Raub, 2002)

In the model of Figure 1, we have described some major issues arising in each life-cycle phase from learning and knowledge creation perspective. The created model consists of five stages: 1) preparation/forming, 2) launch, 3) norming, 4) performing and team development and 5) finishing /disbanding. The preparation phase has been integrated with forming, since they represent the start of the virtual team. Launch phase is presented next, since it is important for learning in the virtual team in creation of mutual knowledge, fostering trust and clarifying the goals. Norming stage in this model comprises of both storming and norming stages of Furst et al. (2004), since the storming stage has been seen as a part of defining the common rules and team practices in norming. Performing stage is the actual productive working phase of the virtual team, and it has been combined with team development, since the team development must be happening simultaneously. Finally, the finishing or disbanding stage from Hertel et al. (2005) has been included in the model because virtual teams are often temporally limited project teams, and according to project learning literature (e.g. Schindler and Eppler, 2003) the last phases of the project and ensuring the sharing of knowledge in the ending phase are important for organizational learning and learning for future projects.

Combining the life-cycle stages to the benefits and challenges that VTs have for learning in each life-cycle stage leads to a framework that has been used as a basis for further development. A summary of the original framework is presented in Stevens et al. (2006), and the challenges and benefits of VTs for learning are discussed briefly in the next sections.

2.2. Challenges and limitations for learning
Virtual teams have several weaknesses with potential effects on learning. The barriers for knowledge sharing have been discussed recently for example by Rosen et al. (2007). Using existing literature, we identified several types of learning challenges that are mainly related to:
- trust,
- creating common understanding due to cultural differences,
- exploiting earlier experience,
- tacit knowledge,
- ICT challenges limiting communication, and
- general team management and leadership.

Trust has been recognized as an important building block for virtual teams (e.g. Gibson and Manuel, 2003; Jarvenpaa et al., 1998; Jarvenpaa and Leidner, 1999). It is also a great challenge from learning point of view because distance and possibly limited communication might lead to slower trust development. Conflicts might also reduce trust and thus diminish the information flows and affect learning capabilities.

The second challenge is related to problems in creating a common understanding and shared mental models. These challenges are closely linked to cultural differences and language, since there is an

increased possibility for misunderstandings because of communication often being reduced to written or spoken language, without the non-verbal signs (Hiltz, 1986). Distance affects the communication frequency and possibilities to understand others, since it often reduces shared values and social similarities (Latane et al., 1995). Cultural differences can also prohibit learning from experiences because of e.g. reduced willingness to tell about mistakes and improvement opportunities.

Exploiting the earlier experiences of the virtual team members might be difficult due to several reasons: challenges in recognizing who knows what (transactive memory) and trusting the expertise of others. The possibility to fully utilize the broader set of competencies offered by VTs may be limited because this potential is not recognized. Transactive memory has been identified as one factor that greatly influences the effectiveness of teams and virtual teams (e.g. Akgün et al., 2005; Austin, 2003) and in VTs the development and maintenance of transactive memory might be limited (Alavi and Tiwana, 2002).

The utilization and transfer of tacit knowledge is difficult in a virtual team because of the distance and limitations of the software-based tools used for communication to support sharing tacit knowledge effectively. Also lack of informal meetings that enable continuous sharing of experiences and learning limits the sharing of tacit knowledge. The tools used can also limit the communication of the team in several other ways, having negative impacts on learning and knowledge generation (Khalifa and Kwok, 1999). The selection of technology affects the available features and supported functions for communication, and might limit the creativity of the team as well as the norms and roles of using different tools (Shachaf, 2008).

Challenges related to virtual team management and leadership from the point of view of learning are for example maintaining the information flow, synergy and common goals. Finding solutions to complex conflicts might be limited in an environment of limited communication (Shin, 2005). In virtual teams, also the challenges of commitment, motivation and communication problems are highlighted, often affecting also the learning possibilities.

2.3 Benefits and support for learning
The benefits or supporting factors of VTs for learning identified in the literature can be divided into the following groups:
- members' expertise
- heterogeneous backgrounds leading to creativity
- cognitive differences and different mental models
- speed of reacting and feedback
- ICT-related benefits

Virtual teams make it possible to use the best available expertise and competences for the tasks, and thus allow also efficient learning through combining the existing knowledge of the team members. Also the versatile local expertise and knowledge of the members is important for innovation activities. Katz and Tushman (1981), as well as Ancona and Caldwell (1990, 1992), demonstrated that successful teams utilized external networks which provided support for finding access to solutions. In their research on communities of practice, Brown and Duguid (1991) revealed that extended competence range may increase the individual capacity to contribute to business functions.

Another benefit supporting learning is the heterogeneous backgrounds of the team, possibly resulting into increased creativity (e.g. Ling, 1990). As cultural diversity extends the scope of individual experiences, it is identified as one of the efficient means for increasing creativity (McDonough et al., 2001).

Related to the different backgrounds of the team members, they have many cognitive differences in the way they process knowledge, as well as many kinds of mental models differing form each other. From the learning point of view, this helps in questioning some seemingly self-evident issues which is seen as a base for deeper, so-called double loop learning, and also helps in recognizing opportunities. In this way VTs can extend the range of potential solutions to existing problems as well as the capacity to invent new solutions (Watson et al., 1993).

Some learning benefits exist due to the speed and flexibility of operations that VTs can offer. They enable fast reacting to changes as well as regular and frequent, fast communication when needed, including review meetings in VT's finalization stage (Lee-Kelley and Sankey, 2008).

ICT-related benefits occur for example in flexible team training, and due to the technology there is a possibility for anonymity, which may in some situations help in conflict resolution. Also, due to cultural and personal reasons, for some people it might be easier to share especially critical thoughts without personalization (Shachaf, 2008).

3. Methodology

Given the small amount of empirical research produced in this field, our qualitative investigation aimed at gathering information on the way managers in charge of developing new projects used the virtual teams. The following points constituted the main concerns: A) Identifying the areas and topics on which virtual teams learned, B) Identifying which phases of the virtual team life-cycle were the most contributive to learning, C) Identifying benefits and limitations of the VTs for learning and ranking the most important of them from participant point of view.

The data came from two sources. First, interviews focused on the use of virtual teams were performed during March-April 2008 in two global leading-edge industrial business-to-business organizations operating in different sectors located in Finland and France. Second, we used data from preliminary interviews, performed between January 2007 and March 2008. They resulted from an in depth analysis of different innovative projects realized in the French B to B -organization.

For the March-April 2008 investigations, an interview guide was created based on the framework of the benefits and challenges resulting from literature review. The respondents were selected according to their previous experience in VT's. In Finland, 6 interviews were organized with 6 persons physically located in Finland or elsewhere. In France, 3 project managers having used VT's for new product development were interviewed. All the 9 respondents have been VT leaders with several years of experience with leading and participating to VTs. Six of them (From the Finnish organization) have received company's internal training in the leadership and managing of VTs. All have managed multinational VTs.

The interviews were organized as face-to-face meetings or phone interviews, realized in English, Finnish and French according to interviewee's nationality, and taped and transcribed afterwards. The documented research material consisted of the interview transcripts and the filled-in questionnaire forms, as well as notes taken by the researcher. In the beginning of the interviews, the respondents answered some open-ended questions on virtual teams, team life-cycle and learning. After the open discussion, they were presented with the picture of the 5-stage life-cycle model (see Figure 1) as well as a list of VT benefits and limiting items for learning that they were first asked to connect to some life-cycle stage between 1 (preparation and forming) and 5 (finishing / disbanding). Then they are asked to rank the importance of the items for learning with a number from 1 to 5, where 5 was the most significant. The respondents gave their explanations for the importance of the benefits or limiting items for learning mostly when they filled in the questionnaire form, but in the end of the interview they were asked to choose 3-5 most important ones from the ones they had marked with importance evaluation 5 as very important and to explain why they had chosen those.

For the January 2007 to March 2008 interviews, 12 respondents were selected based on three kinds of projects: an on-going development project (5 respondents), a finalized and successful project (4 respondents), a finalized and abandoned project (3 respondents). All teams used virtual teams for performing the development. The interviews were focused during the course of the development. The focus was put on the identification of the factors (tasks, events, procedures, etc.) which, from participants' point of view, supported learning. Semi-directive interviews were used. The interviews were recorded and transcribed for analysis.

The interviews were coded and analyzed by researchers in Finland and France according to the language constraints. Analyses were done in parallel and then gathered. As the purpose of the research is to enrich the existing frameworks, parallel accumulation of observation resulted into richer and more detailed perception of the effect of VT on knowledge creation.

4. Results

The results are displayed in three parts. First, we addressed creation, organization, management and processes by which VTs develop new knowledge while innovating. Second, we summarized the contribution and limitations of VTs to learning processes, putting the emphasis on the observations which complement existing statements from literature. Third, we explored the way interviewees classified both contributive and restrictive factors out of the list proposed.

4.1 Knowledge creation by VTs

The interviews revealed that innovative projects are made of two parts, fuzzy front end and formal development stages. It must be emphasized that virtual teams were not used during the early stages of the development. Even though knowledge is produced here, unstable and informal networks, based on existing community of practices are used for gathering, assembling and producing first knowledge. Then, once the project became officially supported by the organization, development teams are officially created. They are not created and labeled as "virtual teams" despite of the way they extensively used IT means for overcoming space and time barriers.

The observations lead to separate two stages in the knowledge creation process. During fuzzy front end stage, the participant or initiator of the projects opted for the use of tacit knowledge, creativity, and access to existing knowledge through informal networks as the most efficient way for generating first solutions to initial problems. Thus, formal VTs were not used during this stage mainly because the overall process remains informal. Once the project survived the initial stages and started to follow formal development guidelines, virtual teams are used as development tool.

During the formal development stages, knowledge was developed about different topics as mentioned in Table 1. It may be observed that when some learning tasks were mostly focused in the external side (Learning related to clients or environment), others were related to internal development (Coordination between functions, for example). The analysis of the interviews highlighted clearly that VTs contributed mostly to internal processes. However, it was mentioned by one participant that, under specific conditions, the association of one leading client within the VT team resulted into significant progress in knowledge generation.

Table 1. Different areas of learning

Learning Areas	Knowledge Generation Operations	Support/Limits of the Virtual Team
Learning related to Clients	Analysing client's demands Testing levels of demand Test acceptance of prototypes Demand forecast	Virtual teams provided opportunities to include members of marketing dpt from different countries. Clients were not included in the VTs.
Learning related to coordination of functions	Compromise Appropriation Sharing mental models Communities Competencies	Virtual teams were very supportive during this kind of operations. It facilitate most of the processes mentioned here.
Learning related to Technique	Gathering knowledge on identified technical problems Testing the solutions	Virtual teams were very supportive during this kind of operation.
Learning related to Environment	Identifying constraints and opportunities in the environment. Integrating the constraints in the project. Associating experts to the project. Testing solutions and alternatives.	Virtual teams provided limited support for this kind of operations, mainly as knowledge generated was related to organisations and individuals which remained out of the firm's perimeter.

Even though the contribution to tacit knowledge appeared to be limited, the observations underlined the positive contribution of VTs to expertise extension as confirmed by the interview grids developed below. Being able to gather rich expertise in diverse fields is one explicit purpose and achievement of the groups. Even though firms did not prepare people explicitly to manage such teams, the engineering culture as well as experience in multinational companies led to positive outcomes, mainly for learning related to technical aspects of the development as well as for the inter-functional coordination.

4.2 VT life-cycle stages and learning
We first analyzed which life-cycle phases the interviewees associated the individual learning-related benefit and challenge issues with. To do this, those issues which were rather unanimously associated with certain life-cycle phases were searched for and highlighted. The respondents could, if necessary, choose to associate an individual benefit or challenge issue to several life-cycle phases, which option was used in several cases. We highlighted those issues which were associated to a certain life-cycle stage by at least six out of nine interviewees (two thirds) to ensure that a clear majority supported the associations. These issues can be seen in the Tables 2 and 3 of the Appendix marked with grey highlighting in the life-cycle part of the tables.

As can be seen from the Tables 2 and 3, using the 6/9 rule, in all cases except challenge 17 (lack of informal meetings), the individual benefit and challenge issues were associated to no more than one life-cycle phase. In this case, the issue was associated to life-cycle phases 2 (Launch) and 4 (Performing and team development). Some challenge and benefit issues were associated relatively evenly and commonly along the course of the whole life-cycle. Such issues included particularly the challenge items 6 (Language misunderstandings) and 22 (Need for more versatile team leader capabilities), and the benefit items 6 (Understanding and learning about local customer needs and solutions), and 18 (Possibility for systematical document sharing and storage in one place). This indicates that the related issues should be considered during the whole life-cycle when learning is aimed to be facilitated in VTs.

Considering the associations of the benefit and challenge issues from the standpoint of individual life-cycle phases, the least commonly agreed associations with the issues have been made with the life-cycle phase 3 (Norming), with no such associations with individual benefit issues, and only one commonly agreed challenge association with challenge issue 15 (Ensuring common understanding), as well as life-cycle phase 5 (Finishing / disbanding), with no commonly agreed benefit and challenge associations and quite few perceived associations altogether. This is interesting, because in the literature and case studies the finishing / disbanding phase has been experienced as an important phase for organizational learning.

Clearly the biggest number of commonly agreed benefit and challenge issue associations can be seen in the case of life-cycle phase 4 (Performing and team development), with altogether 7 (out of 18) commonly agreed benefit issue associations, and 9 (out of 25) common challenge issue associations. The life-cycle phase 4 (Performing and team development) was mentioned altogether most frequently as connected to the individual learning-related issues on both the benefits and challenges of learning. There were 89 mentions (among the available 18 items) connecting a benefit item to LC phase 4, and altogether 117 mentions (among the available 25 items) connecting a limitation item to LC phase 4. This means that on the average, each interviewee has connected phase 4 to about 10 benefit and limitation items. This may indicate that this life-cycle phase is quite complex from the learning standpoint and includes a large number of items to be taken into consideration when facilitating learning in VTs.

4.3 Benefits and limitations for learning
The results concerning the interviewees' evaluation of benefits and challenges of VTs for learning, as well as the interviewees' assessment of which VT life-cycle phases they associate with the individual studied benefit and challenge items are presented in Tables 2 (Benefit items) and 3 (Challenge items) in the Appendix. The results include the counted average of the given importance of the studied items for learning (Avg), and number of respondents evaluating the items.

Benefits commonly seen as important for learning in VTs (average 4.5 or higher) included 4 benefit items (out of 18 available), as can be seen in the Table 2. The items have also been indicated with

bold text. These were the next items in the order of average importance (within the brackets is the number of respondents evaluating the importance to be 5 - very significant):

- 16   Use of short, clear expressions to reduce language misunderstandings and media constraints (6/6)
  - o *4 connected this to LC phase 3 (Norming) and 4 to phase 4 (Performing)*
- 1   Group has best available expertise and knowledge (8/9)
  - o *Most (7/9) connected this to phase 1 (Preparation)*
- 6   Understanding and learning about local customer needs and solutions (4/8)
  - o *Most (6/8) connected this to phase 2 (Launch), 5/8 to phases 1 and 4*
- 18   Possibility for systematical document sharing and storage in one place (5/6)
  - o *Most (5/6) connected this to phase 4 (Performing)*

Challenges commonly seen as important for learning in VTs (average 4.5 or higher) included only 2 challenge items (out of 25 available), see Table 3. The items have been indicated with bold text in the table. These were the following items in the order of average importance:

- 22   Need for more versatile team leader capabilities (5/6)
  - o *Rather evenly (3 to 4 associations per phase) connected with all LC phases from 1 to 5*
- 25   Time constraints due to unrealistic project planning and limited motivation/ commitment (3/6)
  - o *Clearly most (6/6) connected this to phase 4 (Performing)*

4.4 Interviewees' explanations of important factors for learning
The responses were mainly similar to each other and the mentions of the most important issues gathered mostly to same benefits or limitations, leaving about 1/3 of the items without a mention. On the benefits side, the items most frequently chosen as important were also the ones with highest averages. In the challenges however, the responses were different. The explanations given to the selection of most important issues also varied.

With the items chosen as most important in the benefits for learning, the importance of the best available expertise and knowledge was explained through the need to have good basic knowledge and varied levels and areas of specialized knowledge that could be shared, and thus learning would be effective. The need to use short and clear expressions was seen as an important benefit for learning because it improves shared understanding and makes communication effective. The possibility for the VTs to enable learning about local customer needs and solutions was highlighted especially in innovation and development projects as a basic element of the operation of the team, and using ICT tools for training was seen as important especially in the beginning to ensure the skill level, and maintain it later on. The importance of systematical document storage and sharing for learning was justified by the common storage being the most powerful tool of the VT for learning because people need to share and update information continuously.

In the challenges for learning, versatile team leader capabilities were seen as the basis for all VT operation, also learning. The leaders' positive attitude for learning and more coach-like role also was seen to encourage the others in the team. Trust development was seen as another corner stone generally in VTs and for learning, and without it no learning was seen to take place because people wouldn't be willing to share knowledge. Among the items with the highest importance for learning were ensuring common understanding and time constraints due to project planning and limited commitment. The reasons for choosing these as important were firstly, the need for guiding direction through common understanding of the goals and secondly, the need for time, motivation and commitment to enable any learning. The explanations for the selection of ICT and communication tools as important were noticing the various needs of different projects (for example R&D vs. marketing), and the need for backup systems. The tools might even disable the operation of the team, and also prevent any learning.

5. Discussion and conclusions
The benefits that VTs offer for learning that were identified as most important by the interviewees are generally in good agreement with the literature findings. The interviewees were quite unanimous on the best available expertise and knowledge being the most important benefit for learning, as well as

on the importance of using short and clear expressions in VT meetings. Concerning the challenges, the respondents highlighted the role of the team leader capabilities possibly affecting learning. This is also in accordance with the literature, as the need for new kind of leadership in VTs is widely accepted. The leader of the team has an important role in supporting learning and can affect the learning of the whole team, and thus special attention should be paid in VT leadership training to include also learning-related issues. Other important challenges mentioned (trust, shared understanding and time constraints and motivation) are also recognized in the literature.

The interviewees who were all very experienced in VT leadership, agreed generally that the benefit/challenge frameworks used in the evaluation covered well the important aspects that can affect learning in virtual teams. The results thus further validate the preliminary frameworks used. Concerning the tables including benefit and limitation items, all respondents did not fully agree to some individual items as being either a benefit or a limitation to learning. They were seen as either not belonging to the benefit or limitation categories as assigned by the researchers, or the respondents did not see the items as directly connected to VTs. Examples of such items were benefit item 13 (Potential to enlarge the scope of experiences and cognitive maps regarding opportunities), which was seen by one respondent as not connected to only VTs, and benefit item 4 (Easier conflict resolution through anonymous ICT tools), because one respondent stated that anonymity would not help to solve conflicts, and the other not agreeing to easier conflict resolution as being a benefit of VTs.

No further learning-related benefits came up in the interviews, but some challenges were mentioned that were not presented in our benefit/challenge framework. These included the attitudes of the VT members, specifically the attitude or even fear for the VT -related technology and possible resistance due to that, which would limit the learning. Also several issues concerning motivation and commitment, which were more specific than the ones included in the framework were mentioned, such as management support and respect for the other team members. Two of the respondents also mentioned a challenge related to the feeling of belonging to a virtual team, and this being hard to achieve because of being part of several teams or because of lack of permanent physical location. This challenge can have a profound effect on learning in VTs, if the motivation for working in the team and the sense of belonging is missing. Thus it is important for the leaders of the VTs to promote the team atmosphere and to create an identity for the team, so that everyone in the team has a feeling of "being present" and not "falling between teams". In the worst case, neglecting this aspect might lead to losing some of the team members when they choose to leave the company.

As revealed in the different interviews, the major contribution of VTs to learning is to extend the expertise associated to the development project, this resulting into improved capacity in finding solutions to encountered problems. This benefit appeared, however, to be mediated both by the conditions related to the development project and by the conditions under which virtual team is managed. Those observations lead to further research and to managerial recommendations.

First, it was observed that the interest for using VTs during first and informal stages of the development process was limited. Due to the uncertainty related to this stage, it is likely that various types of knowledge management systems, aiming at facilitating the competence and expertise identification, could contribute to locating and sourcing the right expertise. Testing this assumption may be one of the research and managerial recommendations.

Second, as the management of VTs is admitted to be a sensitive and very challenging issue, this receiving strong support in the interview results, and VTs thus requiring an extensive variety of skills and knowledge concerning e.g. general leadership, cultural issues, knowledge management and technology-related skills, research and pragmatic training aiming at the identification of successful managerial skills should be developed. Variables such as managers' versatile capabilities, trust development, and common understanding have to be validated quantitatively and their effect on learning to be explained in more detail.

Third, it was noticed that the VTs contributed more when internal tasks were concerned. It is likely that specific organizational features may facilitate creation of inter-organizational virtual teams. The conditions under which such team may appear and contribute have to be investigated for preparing the next generation of inter-organizational new product development.

Because the importance of learning-related issues is likely to vary in different types of VTs and innovation projects, as also preliminarily seen in the results of this study, an important topic for further research is the related context-dependency of the found benefits, challenges and life-cycle phases in learning and knowledge creation.

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Appendix / Table 2. Benefits of virtual teams related to learning

	In which phase(s) of the VT life cycle primarily (1=preparation, 5=finishing)					Importance for learning (1-5 scale, not at all significant - very significant)					Avg	n
	1	2	3	4	5	1	2	3	4	5		
1. Group has best available expertise and knowledge	7	2	1	2					1	8	**4,89**	9
2. Heterogeneous backgrounds, increased creativity	3	1		6		2		4	3	1	3,06	9
3. Fast reactions to changed customer needs, enabling fast project launch if necessary	1	1		6		1	1	2	2	3	3,56	9
4. Easier conflict resolution through anonymous ICT tools	1	1	3	5	1	4		1	2	1	2,50	8
5. Varied backgrounds, experience and added creativity for sharing and defining new working processes and selecting new technologies to support them	3	2	3	1		1		1	6	2	3,72	9
6. Understanding and learning about local customer needs and solutions	5	6	3	5	2				4	4	**4,50**	8
7. Cognitive differences may also help to question self-evident issues, leading to learning	2	1	1	5	1		1	2	3	3	3,89	9
8. Added creativity for product concept and architecture development	1			7	1		1	4	3	1	3,44	9
9. Regular and frequent inter-team communication and feedback through ICT	1	2	4	5	1	1		3	2	4	3,83	9
10. Utilizing ICT tools for team training	2	2	5	3	1		1	2	2	4	4,19	8
11. Fast reacting to changed customer needs reducing lead-times and time-to-market		1	1	7	1		1	3	1	4	3,89	9
12. Changes are fast to communicate			3	6	1	2		1	2	4	3,67	9
13. Potential to enlarge the scope of experiences and cognitive maps regarding opportunities	2	2	2	5		1	2	1	3	3	3,72	9
14. Possibility for arranging learning –related review meetings faster			2	8	1	1			5	3	4,00	9
15. Easier to share critical thoughts and experiences without too much personalization	1	2	3	6	1	1	4	1	3	1	2,94	9
16. Use of short, clear expressions to reduce language misunderstandings and media constraints	1	1	4	4	1					6	**5,00**	6
17. Better preparation for meetings enabling learning	2	2	2	3	1	1			2	3	4,00	6
18. Possibility for systematical document sharing and storage in one place	2	3	3	5	2		1			5	**4,50**	6

Appendix / Table 3. Challenges of virtual teams related to learning

	In which phase(s) of the VT life cycle primarily (1=preparation, 5=finishing)					Importance for learning (1-5 scale, not at all significant - very significant)					Avg	n
	1	2	3	4	5	1	2	3	4	5		
1. Lacking and slower trust development	6	2		2		1			4	4	4,1	9
2. Faulty first impressions and stereotypes	7	4				1	2	3		4	3,3	9
3. Challenge of recognizing the expertise of others (who knows what)	3	5		2		1	1	3	1	3	3,4	9
4. Recognizing and challenging own assumptions about others' expertise	1	1	1	3				3	2	1	3,7	6
5. Limitations in sharing earlier development project experiences		2	1	8		1	1	1	2	3	3,6	8
6. Language misunderstandings	3	3	4	5	1	1		1	4	3	3,9	9
7. Difficulties in creating and explaining new ideas	1	5	2	5	1		1	3	3	2	3,7	9
8. Limited understanding of others' mental models	1	6	1	4		1	2	1	4	2	3,3	9
9. Cognitive barriers limiting information exchange and learning	1	4	4	6	1	2		3	3	3	3,2	9
10. Conflict situations reducing trust and limiting information exchange		2	4	6	1	2	2		4	1	3,0	9
11. ICT / communication technology selection limiting learning	2	3	3	3		1	1	3	1	3	3,4	9
12. Norms for using ICT as a limiting factor for learning	1	3	4	4	1	2	2	2	1	2	2,9	9
13. Learning time for new tools	2	2	5	3	1	2	1	1	1	4	3,4	9
14. Challenge in unlearning previous experiences	2	4	4	5	2	4	1		2	2	2,7	9
15. Ensuring common understanding	1	4	6	4	2		2	1	2	4	3,9	9
16. Limited utilization of the creativity potential due to ICT restrictions	1	2	2	8	1	2	1		3	3	3,4	9
17. Lack of informal meetings	3	6	3	6	3	1	1		2	5	4,0	9
18. Maintaining a synergy and continuous information flow	1	1	1	9	1		2	1	5	1	3,6	9
19. Reduced ability for finding solutions to complex conflicts	1		1	8	1	1		2	1	5	4,0	9
20. Limited possibility for face-to-face meetings to share experiences and learning	1	3	1	7	2	1	2	1	1	4	3,6	9
21. Limited readiness to talk about problems and improvement opportunities (due to e.g. culture or used technology)	1	3	4	4	1	1	1	1	4	2	3,6	9
22. Need for more versatile team leader capabilities	3	4	3	4	3				1	5	**4,8**	6
23. Formation of sub-groups within the team based on language skills	2	3	1	3	1	2	2		2		2,3	6
24. Failure to understand the roles of different tools	1	3	1	2				3	2	1	3,7	6
25. Time constraints due to unrealistic project planning and limited motivation / commitment	1	2	1	6	1				3	3	**4,5**	6

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