Managing knowledge in dispersed R&D settings
a qualitative study of management challenges
and insights from practice

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and insights from practice

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[Interviewee]: *Here, let me show you something. These are two samples of car coating* (hands the researcher two miniature cars, which look identical).

[Interviewee]: *The samples are completely different. Can you tell?*

[Researcher]: *Well, not from the outside. They are both metallic blue.*

[Interviewee]: *We’ve done our job well, then, if you can’t see the difference. In fact, the coatings of both cars are in essence completely different. The coating of this car* (holding up one) *is specially made for our Asian region. This car* (holding up the other) *is for Europe. They come from two different research platforms.*

[Researcher]: *What is the difference then, if I may ask?*

[Interviewee]: *It starts with weather conditions. If a car coated for Asia ends up in the Netherlands, it will rust away. A European car that ends up in a dry region in Asia will rust away too. Our research platforms know what to do. They’ve developed their own technological approach over the years.*

[Researcher]: *Interesting. Are they like two organizations on their own?*

[Interviewee]: *In some ways, yes. But we do not want to reinvent the wheel. And, moreover, both parties have interesting insights that one can learn from. So they have to realize joint collaborations.*

[Researcher]: *Can you tell me about these collaborations?*

[Interviewee]: *Yes, of course. We have experienced a lot over the years. Do you have time? (laughing)*
This dissertation looks at how organizations manage knowledge, specifically in geographically dispersed research-and-development (R&D) activities. Globalization, the process of the international integration of organizations (amongst other things), has also reached R&D organizations, which aim to concurrently explore and exploit international resources for technological development (e.g., Barkema, Joel, Baum & Mannix, 2002; Gerybadze & Reger, 1999; March, 1991). As the example of a conversation I had with a lead R&D manager illustrates, organizations seek to embed themselves within foreign markets, for different purposes, and this eventually leads to the development of unique, firm-specific resources (Ambos & Ambos, 2011; Ensign, 2000; Kirca, Hult, Roth, Cavusgil, Perry, Akdeniz, … & White, 2005; Knight & Cavusgil, 2004).

While the creation of such international centers of excellence provides organizations with the ability to tap into new knowledge sources and new markets, it also requires investments in terms of management activities to coordinate and integrate knowledge from different sources within one organization. Many international R&D projects do not get off the ground, and it frequently happens that international units are shut down because organizations have difficulty reaping the benefits from their research satellites (Von Zedtwitz, Gassmann & Boutellier, 2004). This dissertation presents a quest into the challenges that organizations face in managing dispersed R&D practices—specifically focusing on knowledge—and it aims to describe how organizations cope with these challenges. In this chapter, I elaborate on the aim of my research, the approach I take, and the overall question I am exploring. I then provide a brief overview of the empirical and theoretical background in which the four studies in this dissertation are grounded, and conclude by presenting the methodology guiding this dissertation and the contributions I make with it.

1.1. Research aim and research question

In recent years, multinational organizations have organized their R&D units in geographically dispersed settings (Frost & Zhou, 2005). These units can be seen as centers of excellence that are based around particular functional and local specializations, and that form a rationalized structure for innovation in a globalized environment (Frost, Birkinshaw & Ensign, 2002; Moore &
Birkinshaw, 1998). By distributing the R&D function, multinationals face changes in how their knowledge can be shared and transferred within their organizations.

Although a lot of organizational knowledge can be shared explicitly, an organization’s most valuable forms of knowledge, such as know-how, expertise, and individual experience, generally remain under-articulated (Alavi & Tiwana, 2002). In cases where R&D is centrally organized, such knowledge can be shared within the shared practice context of engineers and specialists. Yet, in dispersed collaborative settings, this kind of knowledge often remains locally embedded (Meyer, Mudambi & Narula, 2011). Because dispersed centers of excellence are often highly specialized in specific domains, differences in terms of knowledge base between peripheral R&D units and the central organization tend to become even more pronounced. Consequently, managing collaborative and dispersed R&D settings, and integrating knowledge across entire organizations, involve considerable management challenges for both local R&D managers and higher management. Management challenges refer to complicated organizational tasks that can create great benefit for the organization when coped with (Barkema et al., 2002; Klein & Sorra, 1996). Such challenges are the focus of this research. More specifically, this dissertation aims to elucidate how firms manage the simultaneous specialization and integration of knowledge between, on the one hand, R&D units and, on the other, the wider organization.

With regard to the notion that R&D knowledge is difficult to decouple from its context, I adhere to a “practice-based” perspective in which knowledge is conceptualized as inextricably linked to practice—i.e., “knowing is doing”—and consequently, as subjective and embedded in both in people’s practices and in their social contexts (Blackler, 1995; Brown & Duguid, 1991; 2001; Cook & Brown, 1999; Gherardi, 2000; Orlikowski, 2002; Wenger, 2000). Following this perspective, I emphasize the actual processes of the specialization and integration of knowledge itself, in contrast to studies that focus on the output of integration efforts as measured solely by the number of patents filed and generated, for example (e.g., Cummings & Teng, 2003; Frost & Zhou, 2005; Singh, 2008; Song, Almeida & Wu, 2003).

The central research question in this dissertation is:
What are the knowledge-related challenges that firms with dispersed R&D locations face, and how are these challenges dealt with in practice?

Before introducing the four separate studies that were conducted to answer this research question, I first present the practical and theoretical background regarding research on dispersed R&D. Next, I discuss the relevance of this study for theory and practice, and I clarify how the four studies relate to the main research question.

1.2. Dispersed R&D in context

1.2.1. Trends and developments in dispersed R&D organizations

Recent years have witnessed the internationalization of research and development units, in a trend whereby firms move from having centrally organized R&D departments towards running geographically dispersed R&D initiatives (Innovation Union Scoreboard 2013; OECD Factbook, 2013). Growing demands for local market needs, educated human resources, and globalization in general have given rise to a variety of offshores, satellites, and local centers of excellence through which R&D is performed worldwide (Gassmann & Von Zedtwitz, 1999, 2003; Narula & Duysters, 2004). What is interesting in this regard is that R&D is a high-end task that forms the ‘core’ of firms’ business. Although R&D departments have been organized centrally, close to organizations’ headquarters for a long time, and motives for keeping R&D close to the main organization are evident—i.e., R&D is at the heart of creating new and competitive products—the sourcing and organization of R&D have obviously taken an international leap over the last decades (Chiesa, 1996; Dunning & Lundan, 2009).

Before we take a look back to see how R&D has historically developed towards more decentralized structures, we should first look at the internationalization of organizations in general. Internationalization started with international sales, later developing into a physical presence at international locations through local production facilities and the employment of cheap local labor. Often through mergers and acquisitions, companies increased their knowledge of foreign markets. Since the 1980s, in response to the emergence of industry clusters in certain geographic regions (Almeida & Kogut, 1997; Saxenian, 1990) and to differences in supply and
demand in local markets, organizations started foreign R&D units so as to reap the benefits associated with these local settings, thus ensuring that their products would be tailored to local demand and gaining access in the process to unique industrial competencies (Leonard, Brands, Edmondson & Fenwick, 1998; Teece, 1992). Some of these trends and challenges specific to dispersed R&D will be discussed here.

**Starting R&D activities in other countries**

Whereas carrying out R&D internationally used to be a strategy in which the United States led (Boutellier, Gassmann & Von Zedtwitz, 2008), in recent years we have seen organizations from all parts of the world engaging in dispersed R&D in different countries. Big emerging markets can be found, for example, in China, India, former Soviet Bloc countries, Indonesia, South Africa, Poland, Turkey, Argentina, Brazil and Mexico. Multinational corporations (MNCs) start up R&D initiatives not only to accommodate local market needs, but predominantly to gain access to the tremendous amount of science and engineering talent that is turned out by these countries (Boutellier *et al*, 2008; Lewin, Massini & Peeters, 2009).

Two basic strategies for starting R&D initiatives in other countries can be distinguished. The first strategy is aimed at internationalizing R&D through extending already existing departments of the organization in a specific location. Often MNCs have already established departments in a specific country, such as sales and service, thus gaining at least some knowledge of the environment. The second strategy is aimed at the acquisition of existing R&D units. Taking over foreign R&D units can be a complicated process, not only for the organization entering a new country with different cultures and rules, but also for the existing R&D unit with a different organizational background, and its own culture, structure and management (*e.g.*, Makri, Hitt, & Lane, 2010). For example, in one of the case studies in this dissertation, a Dutch MNC took over an Indian R&D organization in Bangalore. After a difficult start-up period, headquarters in the Netherlands decided to reorganize the Indian unit in order to improve alignment between the Indian unit and the MNC’s units in the US and the Netherlands. Managers and science and engineering talent were relocated to new functions according to their capabilities and experience. Still, the reorganization failed, because the organization did not take into account the traditional caste system in India, which strongly influenced hierarchical positions in the
Indian unit. It turned out that people with a lower caste classification were placed in higher positions than people with a higher classification, which in practice was something the Indian employees could not cope with.

**Sharing knowledge in dispersed settings**

Whereas in central R&D settings there are opportunities for face-to-face communication (formal as well as informal), such communication is complicated in dispersed settings. The role of information and communication technology (ICT) in such settings is crucial in that, besides overseas visits, ICT often offers the only channels through which communication and collaboration can take place. With the worldwide connectedness of ICT these days, R&D locations in every country can connect and share information through these channels in real time. Many organizations invest heavily nowadays in video conferencing, shared intranets and databases, shared computer-aided design (CAD) software, and other ICT-related ways to connect professionals across the globe.

Both developed and developing countries become attractive to MNCs seeking start up foreign R&D operations, because these gradually provide better access to information flows. Virtual R&D communities, spread over many different R&D units, arise and increase knowledge-sharing within companies. Especially where R&D work can be decoupled in parts and transferred through ICT, organizations are able to perform R&D across geographically dispersed locations and projects. Overall, we see that knowledge flows change, and that more network-structured arrangements arise (Boutellier *et al*, 2008).

However, organizations must rely on their ICT for knowledge-sharing in dispersed projects, and this can be a complicated task for management, while confronting information technology departments with serious challenges. According to Boutellier *et al* (2008: 25), the optimal use of critical knowledge resources is hampered because of “conventional barriers to innovation, information overflow, and suboptimal use of information and communication technologies….Often a strategic approach to knowledge management is missing….An intelligent approach has to differentiate among types of knowledge, using instruments like technology intelligence, selective knowledge bases, systematic knowledge engineering, patent offices, competitor analysis, knowledge diffusion and last but not least intrinsic motivation of R&D
people.” Moreover, some countries have strict regulations when it comes to intellectual-property rights, thus making the sharing or transferring information to other countries complicated (Grandstrand & Holgersson, 2013). China, for example, follows strict rules on the transfer of intellectual property. Knowledge that is created in China is supposed to be applied in China. Consequently, when an organization develops concepts for a new product line, the project cannot be transferred to another country easily, and further development and additional gains are supposed to be exploited in China. Regulations on intellectual property strongly determine where certain parts of the R&D process can be located in other countries.

The above examples give an initial sense of some of the difficulties that organizations face when managing knowledge in dispersed R&D settings. ICT enables organizations to work in geographically dispersed locations, but only to a certain extent. If we take a close look at what sort of knowledge is involved in R&D work, and how knowledge in dispersed settings becomes even more specialized and embedded in its local context, it becomes clear that it is often difficult or impossible to share or transfer such knowledge through ICT at all. The next section takes a closer look at the specifics of R&D work and knowledge, and explains some of the main difficulties management faces with dispersed R&D.

1.3. Theoretical concepts

1.3.1. Knowledge and R&D work

Before I elaborate on R&D work and knowledge, it will be useful to discuss the concept of knowledge more generally. The term “knowledge” is defined in many different ways, for many different purposes. The Oxford Dictionary defines knowledge as “the theoretical or practical understanding of a subject.” The concept of knowledge in this dissertation requires a broad definition, involving many different characteristics of knowledge. Knowledge can be tacit, explicit, implicit, local, or global, but also be divided into know-how, know-who, know-why, etc. (e.g., Roberts, 2000; Smith, 2001; Teece, 2003). Knowledge can be understood by different people in different ways. A technical report, for example, will likely be ill understood by someone without a specific technical background. The reader has to understand the technical basis for the report, the design choices that have been made in producing it, and the context it has
been written in. The theory of knowledge tells us that knowledge can be tacit or explicit, and is often a combination of the two. Implicit knowledge can be made explicit in part, but the recipient of such knowledge should have some prior knowledge in order to understand it (Nonaka & Takeuchi, 1995; Polanyi, 1962).

Furthermore, knowledge can be local or global. Local knowledge is knowledge that is specific to a context and often resides implicitly in people, practices and routines. It is embedded within its context and difficult to transfer. This makes it unique and therefore potentially valuable. Global knowledge is knowledge that has been made more generally available to other parts of the organization. This is achieved not only by codifying the knowledge in databases and reports, but also through education and training. This again denotes how knowledge often consists of tacit and explicit elements, and it is this combination that can make knowledge valuable (Nonaka & Takeuchi, 1995).

Yet another conceptualization of knowledge distinguishes between know-what, know-how, and know-who (e.g., Lundvall & Johnson, 1994). Know-what knowledge is, for example, what you did yesterday (Lazaric & Denis, 2005), or knowledge of specific problems solved earlier (Bunch, 1936). It is developed through the direct encoding of environments, by such activities as observing, studying, and listening (Anderson, 1983), and may reside in people as well as in material forms such as databases and reports (Moorman & Miner, 1998; Walsh, 1995). Know-how closely relates to individual skills and habits. It represents knowledge of how things are done, and is manifested in people’s performances and actions (Anderson, 1982; Lynn & Akgün, 2000). This type of knowledge is difficult to articulate (Lynn & Akgün, 2000), it is often tacit (Nonaka, 1990), involves low conscious awareness when acquired or used (Cohen & Bacdayan, 1994; Squire & Kendall, 1999), and mainly resides on the individual level (Pentland & Feldman, 2005). It can reside in people and material forms, but much more implicitly than know-what. Know-who provides people the ability to access knowledge from others that they themselves do not possess (Argote & Ren, 2012). It is typically developed through interactions in practice. People become aware of others’ expertise during the work itself, and contact these persons for further advice on problems they cannot solve with their own expertise. Locating this expertise and building transactive memory is highly triggered by interactions such as direct
contact, direct collaboration, and referral to expertise by other persons (Hollingshead & Brandon, 2003; Lewis, 2003).

This overview shows that knowledge is a multi-dimensional and rich concept. Within the context of R&D work, a number of specific issues related to knowledge can be identified. Dougherty (2001) identifies three specific characteristics of R&D work: such work is integral, situated and emergent. The integral nature of R&D refers to the interrelatedness of activities that are part of R&D, and emphasizes the importance of integrating knowledge across various specializations. In R&D, different knowledge domains are combined to form the knowledge assets necessary for problem-solving and innovation (Clark & Fujimoto, 1991; Kogut & Zander, 1992). An important element of the integration of knowledge from across different domains is the process of heedful interrelating (Weick & Roberts, 1993). This is the process in which individual knowledge workers contribute to integral work by understanding the system of joint action, and then relating their contribution within this system to solve problems or develop new products (Dougherty & Takacs, 2004). A combination of know-what, know-how, and know-who is essential for this process to take place, and it strongly depends on the opportunity to meet face to face and actively collaborate (Clark & Fujimoto, 1991; Leonard-Barton, 1995).

Second, R&D work is situated in a practical and social context (Brown & Duguid, 2002; Lave & Wenger, 1991; Tyre & von Hippel, 1997). This means that R&D work should be “understood as involving both a body of practice, manifest in the artifacts and techniques that are produced and used, and a body of understanding, which supports, surrounds, and rationalises the former” (Nelson, 2004, p.457). Knowledge creation, sharing and application are situated within the context of a shared practice around which direct collaboration takes place (Brown & Duguid, 2001). In order for R&D workers in a particular unit to fully understand the meaning and purpose of technologies created in another unit, they have to understand the context in which the knowledge was created.

Third, R&D work is characterized by the emergent nature of working standards. This means that innovative work requires flexibility in adjusting the formal configuration of the process during the practice itself. Typical for R&D work is that there is no clear-cut program that leads towards the creation of the end-product, and the innovation process may go in different
directions in order to create an optimal end product. This means that R&D projects benefit from flexible work processes in order to further develop technologies that are at hand. (Dougherty, 2001; Tatikonda & Rosenthal, 2000; Van de Ven & Poole, 1987).

In sum, the concept of knowledge as adopted in this study has many characteristics to include when studying knowledge management in dispersed R&D. The three characteristics of R&D include, and explain the meaning of, many of these characteristics, thus showing the complexity of knowledge involved in R&D work. Besides specific characteristics of knowledge, there are also several views on how to study knowledge in organizations, and several R&D objectives that affect how knowledge can develop in organizations. For the studies in this dissertation I have adopted two main objectives, namely specialization and integration, and two primary perspectives, namely a KBV of the firm and a practice-based perspective on knowledge, which are further introduced below.

1.3.2. Knowledge specialization and integration

Knowledge specialization and integration are two related knowledge-management objectives for multinational organizations. Because R&D work entails specialization and integration, both objectives are frequently discussed in the literature (e.g., Almeida & Grant, 1998; Chiesa, 1996; Postrel, 2002; Teigland, Fey & Birkinshaw, 2000). The first objective is to develop specialized units of excellence that create competitive value through specialization in certain knowledge domains. Specialization, or differentiation (Lawrence & Lorch, 1967), is something that global R&D organizations can achieve by starting up or acquiring separate units in locations that foster exploration and exploitation in a specific knowledge domain (industry clusters, local markets). Each R&D unit develops its own excellence, its own way of working, and its own routines, language, culture, and so on. An R&D unit embeds itself in its local context and develops its own logic to fully understand local knowledge, and to combine and recombine this knowledge with experience and know-how on the part of specialists and engineers in practice, so as to create new knowledge (Brown & Duguid, 1991; Sole & Edmondson, 2002).
The second knowledge-management objective for multinational organizations is the ability to achieve organizational knowledge through integrating these pockets of specialized knowledge into the wider organization (Grant, 1996). Newly created knowledge is recognized as an important asset that can be exploited as a resource by other parts of the organization (Alavi & Leidner, 2001). For example, if the organization creates more and more understanding of a certain technology, it might find more-efficient ways to develop the technology, or be able to use the technology as a solution, or part of a solution, in other parts of the organization. The literature describes knowledge integration in different ways that are applicable to the studies in this dissertation. The literature on knowledge-sharing refers to the “deployment of knowledge in communication with others” (Berends, Debackere & Weggeman, 2006: p. 85). The literature on knowledge integration refers to “an ongoing collective process of constructing, articulating and redefining shared beliefs through the social interaction of organizational members” (Huang, 2000: p.15). The literature on dynamic capabilities refers to knowledge integration as the systematic ability to integrate resources to enhance performance (Grant, 1996b; Zollo & Winter, 2002). Furthermore, knowledge integration can take place on several organizational levels, such as the team (Gardner, Gino & Staats, 2012), project (e.g., Collinson, 2001), and organizational levels (Grant, 1996a). In this thesis the definition by Huang (2000) as cited above is adopted. The definition is applicable to different organizational levels, and it contains a notion of time, people, and interaction. These are important aspects throughout the studies in this thesis and therefore fit the overall research question.

Knowledge specialization and integration are central to the KBV of the firm, as discussed in the following section.

1.3.3. Perspectives on knowledge

The knowledge-based view (KBV) of the firm considers knowledge to be the most strategically significant resource of an organization, because knowledge within organizations is usually difficult to imitate and socially complex, and is therefore seen as a major determinant of sustained competitive advantage (Grant, 1995; Spender, 1996; Kogut & Zander, 1992). According to the KBV, knowledge creation relies on specialization, which means that an
organization consists of a collection of heterogeneous knowledge assets, and that the objective of the firm is the integration of these heterogeneous assets (Grant, 1996b). If we see knowledge as a critical and sustained resource of the organization for which integration is required, the management of knowledge takes on the utmost importance for long-term organizational performance (Ensign, 1999).

An overlapping view, which nevertheless has a different point of departure, is the practice-based perspective on knowledge. This perspective emphasizes the collective, situated and provisional nature of knowledge, as well as the social, historical and structural context in which practices and knowledge are embedded (Bourdieu, 1996, Brown & Duguid, 1991; Carlile, 2002; Gherardi, 2000; Lave & Wenger, 1991; Orlikowski, 2000; Sole and Edmondson, 2002). According to this perspective, knowledge is created during practice by doing, i.e., by accumulating experience (Wenger, 1998), and likewise a large part of knowledge in organizations is actually about knowing, i.e., acting knowledgeably as a routine part of daily work (Orlikowski, 2002). From a practice-based perspective, it is difficult to understand how this specialized knowledge can be extracted and transformed into organizational knowledge that is useful for other parts of the organization.

The KBV and the practice-based perspective both explain the role of knowledge in organizations, but from different stances. I adopt and explain the KBV throughout this dissertation to denote the underlying objectives for management, namely the realization of knowledge integration in dispersed R&D settings. I also adopt the practice-based perspective, which focuses more on the process and conditions for knowledge creation and the embeddedness of knowledge itself. This perspective provides a better understanding of how specialization takes place, and how knowledge that is created in a particular context is intrinsically bound to this setting, and the practices, routines and people involved.

In this dissertation I take both views as a duality, as they are fundamentally interdependent in practice settings in the case studies presented. Seeing both views as a duality potentially makes a contribution to practice as well as to both theoretical views. By adopting a practice-based perspective, I aim to identify what challenges for management derive from the practice of R&D work itself, and by combining these insights with the KBV, I aim to provide a more in-depth
understanding of how such challenges can be met in regard to managerial objectives for the organization of R&D.

1.4. Relevance and fit

Past research on managing knowledge in global R&D settings has provided valuable insights by focusing on management issues. Alavi and Tiwana (2002) for example, have investigated collaborations in virtual teams, identifying four key constraints for knowledge integration: (1) shortcomings in transactive memory (knowing who knows what), (2) a lack of mutual understanding between people and units that are not co-located, (3) difficulties in grasping contextual knowledge (why are choices in design made?), and (4) weak relationships between locations, which inhibit the creation and sharing of knowledge. Frost and Zhou (2005), who conducted a longitudinal study in the automotive and pharmaceutical industries, found that collaboration between dispersed R&D units over the years increases social capital and absorptive capacity between units, thus augmenting the likelihood that more-effective knowledge-sharing and creation emerge. These studies address the complexity of integrating specialized knowledge from different R&D locations and emphasize the need for further empirical research that can identify key processes that relate to both specialization and integration efforts and take a closer look at how MNCs deal with some key management challenges in practice (for example, Birkinshaw, 2002; Huang & Newell, 2003). This dissertation aims to identify such key challenges, particularly focusing on how management copes with the challenges deriving from managing knowledge in global R&D in practice. In defining management challenges I adopt a concept from earlier work on management challenges in innovation management that sees them as complex organizational tasks for management that can provide organizations with significant benefits when they are carried out effectively (Barkema, 2002; Lahiri, 2010; Van de Vrande, De Jong, Vanhaverbeke & Rochemont, 2009).

The central research question of this dissertation, as set out in the beginning of this section, consists of two parts. The first aims to identify some of the main knowledge-management challenges that managers face in coping with dispersed R&D settings. The second part of the research question consists of a “how” question that is aimed at gaining insight into
how management copes with these challenges. The four studies that follow each provide some part of the answer to this research question, as depicted in Table 1.1. This table presents an overview of the studies, the sub-research question each study addresses, and the aim of the studies.

Chapter 2 presents the first study of this dissertation and investigates what factors influence knowledge integration in dispersed R&D settings. This study sets the scene by exploring the factors that complicate or facilitate the integration of knowledge in dispersed R&D. The study reveals several important factors at the level of the knowledge itself, the local unit, and the relationships between units, and makes clear the importance of understanding the practice setting in which knowledge is created and collaboration takes place. Chapter 3 builds on this notion of understanding the practice setting, and reports on a case study of a collaborative project between a Dutch and a Canadian R&D unit, giving a picture of the complexity of such a knowledge-intensive dispersed collaboration project. The case study describes how collaboration tools such as computer-aided design (CAD) systems and wikis (corporate Web applications for collaboration) can foster or hamper a shared practice setting. The study points to the challenge both of realizing knowledge specialization and integration between different groups and of introducing the complexity of managing embeddedness in dispersed settings. Chapter 4 also builds on a practice perspective and reports on a case study that describes how engineering consultants can bridge the gaps between practices and knowledge in dispersed organizational settings. The challenge of coping with embeddedness is central to this third study. The study’s findings describe how a combination of organized learning, learning in practice, and transactive memory contribute to a process I refer to as knowledge pollination, and which explains how the work of engineering consultants can support knowledge integration in dispersed settings. The study I look at in chapter 5 takes into account the previous studies, and provides a comprehensive overview of different R&D management processes and at how these processes are related. This study describes the tension between specialization and integration processes, identifies specific practices that support the management of this tension, and points to R&D processes that should be taken into account in this regard, such as establishing connections and articulating content. The chapter concludes with a discussion of the importance of understanding the interrelatedness
between several R&D processes from a managerial perspective, and offers insights into how managers learn to fine-tune such processes.

### Table 1.1: Overview of the different studies

<table>
<thead>
<tr>
<th>Chapter 2</th>
<th>Main research question:</th>
<th>Aim:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Chapter 3</th>
<th>Main research question:</th>
<th>Aim:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary objects in new joint fields</td>
<td>How does knowledge integration take place in practice, in collaboration between R&amp;D units?</td>
<td>Empirical study to develop understanding of knowledge integration in collaborative practice settings. Examination of the use of collaborative tools and specifics of a shared practice setting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 4</th>
<th>Main research question:</th>
<th>Aim:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge pollination: facilitating organizational learning in geographically dispersed settings</td>
<td>How can the embeddedness of knowledge be coped with in integrating dispersed R&amp;D knowledge?</td>
<td>Empirical study to investigate from a practice perspective how the embeddedness of knowledge in dispersed settings is coped with. Identification of what mechanisms knowledge workers themselves are involved in in practice.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 5</th>
<th>Main research question:</th>
<th>Aim:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialization and integration in dispersed R&amp;D settings</td>
<td>How can the specialization and integration of knowledge be managed in dispersed R&amp;D settings?</td>
<td>Empirical study that examines processes of specialization and integration that influence each other at different levels. Identifying fields of attention and specific practices that support the management of the tension between specialization and integration.</td>
</tr>
</tbody>
</table>

### 1.5. Research methods

The research aim and the research question of this dissertation have an exploratory nature: to identify knowledge-related challenges to managing dispersed R&D, and to offer insights into how organizations deal with this in practice. Such exploratory questions demand a qualitative
research design. I conducted semi-structured, in-depth, face-to-face interviews, but also collected company documentation, attended meetings, and made observations, which I subsequently used in the analyses of the different studies. The data provide ample insights into knowledge management in dispersed R&D, something that cannot easily be achieved through quantitative studies (Eisenhardt & Graebner, 2007; Shah & Corley, 2006; Siggelkow, 2007; Yin, 2008). By conducting interviews in multiple organizations in several locations, and on different projects, I was able to describe the relevant knowledge-management challenges and processes in detail. This provided in-depth practical insights.

Several scholars recommend such practical insights as a point for further research. As considerable research is done in the field of dispersed R&D knowledge, much of it has focused on quantitative data analysis, such as patenting records (Lahiri, 2010; Singh, 2008) or questionnaires (Birkinshaw, 2002; Cummings & Teng, 2003). This dissertation follows up on a call for more-in-depth qualitative research, emerging from the practice of performing dispersed R&D itself. For example, Gerybadze and Reger (1999) suggest further qualitative and empirical research into managing R&D between locations, and at lower levels than only corporate R&D. Sole and Edmondson (2002) found that co-located teams lack understanding of practices and routines followed by dispersed teams, and hinted at the need for further research into dispersed versus co-located teams. This dissertation touches upon these subjects, providing a more detailed description of the practices and processes that engineers and specialists are involved in, and analyzing how local and higher management anticipates these.

In order to clearly understand the practices of managing knowledge in dispersed R&D settings, an inductive research approach is chosen (Eisenhardt & Graebner, 2007). Inductive research considers two general steps (Mintzberg, 1979). The first, described as detective work, searches for patterns and consistencies in data. The second is the creative leap that researchers themselves take by generalizing beyond the data and providing new theoretical insights. This approach is taken in all four studies. The overall topic of managing knowledge in dispersed R&D, the findings of previous studies, and a priori theory were available at the beginning of each separate study, but in every study the specific focus developed during efforts to gather and analyse data. For example, the study in chapter 3 started with general interviews on knowledge
management in global R&D at the headquarters of Graphic in the Netherlands. After three in-depth interviews with vice-presidents and lead managers of corporate R&D, an interesting collaboration between a unit in Canada and the Netherlands was brought up. After some interviews at both sites, attention was drawn to a specific collaborative project. Because some interesting in-depth stories became evident during follow-up interviews, this then became the focus of the study. Specifically, through interactions among practice, existing theory, emerging theory, and discussions amongst the research team, new insightful perspectives were being developed (Eisenhardt & Graebner, 2007; Gioia, Corley & Hamilton, 2012; Langley & Abdallah, 2011; Shah & Corley, 2006). This resulted in each study’s taking a different turn towards the research aim, having different levels of analysis (i.e., practical versus managerial), different scopes (intra-unit, inter-unit and organization-wide), and eventually different theoretical insights developed.

Almost all interviews in this study were conducted in person, at the work place of the interviewee. They were conducted in the Netherlands, the US and Canada. Interviews by phone were held in the Netherlands for the most part, with interviewees connecting from China, India, England, and the Netherlands. All interviews were fully transcribed, mostly by myself. The process of transcribing allows for review and analysis by the researcher, as well as strong engagement with the case study at hand. Analysis of the interviews was done through coding in Atlas.ti. This is a software program that allows overviews throughout different interviews, of different interviewee-groups (management, engineers, locations, organizations), and according to different coding constructs. Analysis of the data was done with the research team, theory at hand, the interviewees, and the companies involved in the case studies. A detailed description of the timeline of the studies, the analysis and coding process can be found in the methods section of each of the four studies, in chapters 2 to 5. Each chapter also provides more extensive coding schemes in the appendices. Table 1.2 provides an overview of primary data (interviews) gathered and used in each study.
Table 1.2 Overview of interviews

<table>
<thead>
<tr>
<th>Companies</th>
<th>No. of Interviews conducted</th>
<th>Timeframe</th>
<th>Transcriptions used</th>
</tr>
</thead>
</table>
| A (‘Graphic’) | 33 | March 2009 – July 2010 | Chapter 2 (3)  
Chapter 3 (33)  
Chapter 5 (33) |
| B | 5 | April 2009 – May 2009 | Chapter 2 (5)  
Chapter 5 (5) |
| C | 4 | March 2009 – April 2009 | Chapter 2 (4)  
Chapter 5 (4) |
| D (‘EnerTech’) | 23 | April 2009 – December 2011 | Chapter 2 (1)  
Chapter 4 (23)  
Chapter 5 (23) |
| Total | 65 | | |

1.6. Contribution of this dissertation

So far I have introduced the aim, the studies of this dissertation and the research strategy of this dissertation. The four studies will be presented in the next chapters. Each study addresses an alternative focus on the main research question, and together they provide some broad contributions to our insights into knowledge-management issues in dispersed R&D settings. As I explained in the beginning of this chapter, many international R&D projects do not get off the ground, and it frequently happens that international units are shut down because organizations have difficulty in realizing dynamic, dispersed settings. Few studies have been done as yet that would give us a good understanding of how tensions between the specialization and integration of knowledge are managed. These tensions dramatically influence how knowledge is shared and developed throughout the organization. This dissertation provides several theoretical and practical contributions.

At a theoretical level, we can improve our understanding of three main challenges organizations face—first, of how organizations cope with the greater embeddedness of knowledge in dispersed settings. Embeddedness will be discussed as a phenomenon that both is vital to and hinders knowledge creation, and the concept will be addressed at several levels (knowledge, unit, relational). Second, efforts to specialize and integrate knowledge are analyzed in relation to each
other, thus providing an understanding of how to manage the tension between them. Third, I expound on several knowledge-transfer mechanisms that are adopted in a number of empirical studies, and offer insights into how formal and informal knowledge-transfer mechanisms can play a role in dispersed R&D settings.

As regards practice, this dissertation makes three main contributions. First, the separate studies and the discussion in chapter 6 unfold the broad variety of different contexts that organizations must be aware of when managing R&D activities in dispersed settings. Examples that will be discussed include differences in practices, tools, management style, routines, and the lack of a shared practice context through which to collaborate or to share knowledge. Second, the differences between organizing for central R&D and organizing for dispersed R&D are evident and have clear implications for different approaches to managing knowledge in such settings, and these implications will be discussed. Third, although there is a tendency to increase formalization in dispersed settings, this dissertation addresses the importance of self-organizing processes in central settings and discusses the importance of combining top-down and bottom-up approaches to managing knowledge.

The implications, taken together, add to our understanding of how MNCs try to manage knowledge within their R&D organization, and discuss how geographically dispersed R&D projects can be organized. By combining a KBV of the firm and a practice-based perspective on knowledge, this dissertation offers a thorough understanding of how management can cope with specific R&D challenges to managing specialization and integration, embeddedness, and knowledge-transfer mechanisms in dispersed settings.

1.7. Related publications

Table 1.3: Related publications

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Output</th>
</tr>
</thead>
</table>


Erkelens, R., Van den Hooff, B.J., Huysman, M.H. & Vlaar, P. 2013. Knowledge pollination: facilitating organizational learning in geographically dispersed settings. *Essay was among the top 15 candidates for an Australian international PhD competition by the University of South Australia School of Management to participate a three-day forum on management in the 21st century. November 2013, Adelaide (Australia).*


This chapter reports on a qualitative study that I conducted at R&D departments in various MNCs and that investigated the intricacies associated with managing knowledge integration across dispersed R&D locations. Taking into account the KBVKBV of the firm and the practice-based view of knowledge, and building on the literature concerning the specialization and integration of knowledge within organizations, I explore which factors may have a significant influence on the integration of knowledge between R&D units. The findings indicate (1) what contribution has been made by a number of factors that influence knowledge-integration processes and (2) the need for a thoughtful balance between deliberate and emergent approaches so as to understand and overcome knowledge-integration issues.
2.1. Introduction
In recent years, MNCs have increasingly adopted a global approach to research and development (R&D) activities. They have been (partly) relocating their R&D function in response to push factors such as a lack of talent and mounting cost pressures in their home countries (Pro Inno Europe, 2007), and pull factors in countries such as highly skilled science and engineering talent and greater proximity to their customer bases (Lewin, et al, 2009; Trefler, 2005; Von Zedwitz & Gassmann, 2002). According to the 2009 World Investment Prospects Survey (UNCTAD), this trend of relocating R&D will continue in the years to come, with Asia—primarily China and India—as preferred locations.

By ‘offshoring’ various R&D units overseas, companies create dispersed knowledge centers, or centers of excellence, with each unit having its own specializations (Moore & Birkinshaw, 1998). In order to reap the benefits of specialization, organizations try to integrate knowledge from different R&D units into their “R&D network”, i.e., combining specific knowledge held by individuals in order to exploit and generate new combinations of existing knowledge (Kogut & Zander, 1992). The development of new products in particular involves wide-ranging integration between specialist knowledge bases constituted by a number of individuals (Clark & Fujimoto, 1991; Grant, 1996b: 377). In keeping with this view of the development of new products, Singh (2008) argues that, while the geographical distribution of R&D does not necessarily increase the quality of a company’s innovative output in itself, the integration of knowledge from multiple locations can make specialization valuable. Hence, though specialization can be seen as the motive for global R&D, it is the integration between different specializations that makes global R&D successful in practice. This conforms to the KBV of the firm (e.g., Grant, 1996a), which argues that effective knowledge creation relies on specialization by individuals or units (thus leading to a collection of heterogeneous knowledge assets), and on the firm’s acting as a vehicle for the integration of these knowledge assets.

Scholars have observed the need for both knowledge specialization and integration. Postrel, for example, argues that “mutual ignorance across specialties is usually optimal” for the development of specialization, but that the development of knowledge also benefits from certain key interactions between these specialties (Postrel, 2002: 304). In other words, managing
knowledge involves a tension between specialization on the one hand (in order for specialized
knowledge creation to occur) and integration on the other hand (in order for the organization to
be able to benefit from the combination of various pockets of specialized knowledge) (Grant,
1996a). Yet the process of knowledge integration itself, often realized by setting up cross-
functional, multisite projects, is challenging (Clark & Fujimoto, 1991). Integrating specialist
knowledge means bringing individuals together and helping them understand each other, thus
allowing cross-functional learning, and combining and applying new knowledge. In the context
of geographically dispersed R&D units, integration processes are likely to be influenced by such
factors as differences in knowledge bases, communication problems, different ways of working,
distinct cultures, and time differences. In this study, I explore factors that may have a significant
influence on the process of knowledge integration in particular, and how firms and key
stakeholders cope with the associated challenges in practice. Hence, my research question in this
study is: What factors influence knowledge integration in dispersed R&D settings?

To structure my analysis, I use an inductive exploratory approach. Since I aim to make a
theoretical contribution to the relatively new subject of the integration of dispersed R&D
activities, I rely on semi-structured, in-depth interviews with managers and key informants
directly involved with global R&D, aiming to establish which factors considerably influence the
integration of knowledge between distinct units in global R&D networks. I have conducted 12
interviews with representatives of 4 MNCs that are developing global R&D networks.

The findings illustrate the tension between, on the one hand, the specialization of different
units in the R&D network, and, on the other, the need to integrate the knowledge held by
different units to fully capture the benefits of specialization in practice. Specialization within
units can be facilitated, for example, by defining strategy and scope, formulating boundaries, and
the concentration of specific activities in one unit. The integration of knowledge from across
units (or specialization between units) requires a more emergent approach to the management of
global R&D networks. More specifically, findings indicate that the integration of knowledge
amongst units relies on: (1) factors related to the units involved in these processes; (2) factors
associated with the knowledge being created and shared, and: (3) factors associated with the
relationships between distinct organizational units. First, on a unit level, the findings reveal
factors of dominant logics and cultural awareness to influence the integration process. Second, in terms of the knowledge being created and shared, knowledge integration is largely dependent on similarity of knowledge bases, and the embeddedness of knowledge. As a consequence of specialization, specialist knowledge becomes more embedded in the people, tools, routines and sub-networks of one unit, while in order to understand the value of knowledge possessed by other units, knowledge should be partly embedded in the relationship between units (e.g., Nielsen, 2005). Third, with regard to the relationship between R&D units, I found structural and relational embeddedness to be important factors that facilitate knowledge integration. Structural embeddedness in this regard is something that management can manage deliberately, while relational embeddedness is something that is enabled by structural embeddedness, and more difficult to manage because it is more complicated.

The main contribution of this study is to build on these findings and thus to identify some of the main factors influencing the integration between geographically dispersed R&D units, while also illustrating that this integration relies on a combination of both a deliberate management approach, as advocated by the KBV of the firm, and a more emergent approach towards knowledge that supports a practice-based perspective. Whereas previous research pertaining to this setting has mainly approached the tension between specialization and integration from a deliberate management perspective, my findings show that the emergent nature of knowledge processes should also be taken into account in order to achieve a balance between the specialization and the integration of globally dispersed R&D activities and knowledge.

2.2. Theoretical background
The shift towards a more international view of R&D, as described above, is characterized by intense market and technology interaction, cross-functional learning, interactive technology transfer between locations, and multiple centers of excellence that are geographically dispersed (Gerybadze & Reger, 1999). A center of excellence can be defined as “an organizational unit that embodies a set of capabilities that has been explicitly recognized by the firm as an important source of value creation, with the intention that these capabilities be leveraged by and/or disseminated to other parts of the firm” (Frost et al, 2002:1000). Within such centers of
excellence, specialized knowledge is developed: scientific and technical knowledge concerning product or process innovation, as well as knowledge about customers and competitors, and knowledge underpinning several organizational capabilities (Collinson, 2001).

Specialization is the main underlying principle for the firm (Williamson, 1985). Yet, according to Birkinshaw (2002), the ability to integrate knowledge held by different units—referring to the bringing together and combining of different knowledge sources in an organization—is crucial to R&D networks and the aim of generating new capabilities—for example, the relatedness of technological competencies (Ramanujam & Varadarajan, 1989), spatial cultural distance, whether interactions take place across national borders, formal organizational structure, informal cross-subsidiary relations between specialists (Foss & Pedersen, 2003; Granovetter, 1985; Hansen & Løvas, 2004), and the characteristics of the knowledge involved (Kogut & Zander, 1992).

Where R&D benefits from the simultaneous specialization and integration of knowledge, a tension can be found between dispersing and assimilating specialist knowledge. As Collinson (2001) argues, “there is a difficult balance between specialization and the ‘fragmentation’ of knowledge—i.e., its distribution into specialist functional divisions—and the need to integrate specialist knowledge for particular tasks.” Correspondingly, Postrel (2002) argues that specializations should be separated for an optimal concentration in that specialty but that certain kinds of specialist knowledge can develop when they interact with other kinds. Previous research in the area of specialization and integration has identified various ways of coping with the tension between the two. For example, Puranam, Singh, and Chaudhuri (2009) have studied the post-merger integration of technological capabilities and found that structural integration can negatively influence the innovative capabilities of the firm because of the disruption of a unit’s autonomy, which subsequently inhibits the innovative capabilities of that unit. They furthermore suggest that realizing common ground between units can facilitate coordination and that it can work as an alternative way to benefit from the combination of knowledge from different specialists. Building on a network perspective, Hansen and Birkinshaw (2007) suggest that cross-unit networks can stimulate the conversion of ideas in the organization because they allow new connections between different specializations to be established. Song and Shin (2008) argue
that, when a host unit’s technological capabilities are superior to that of the headquarters unit, knowledge integration is more likely to occur, because of the potential value that this new knowledge can bring to the organization. Another example can be found in Singh’s (2008) study on informal integration mechanisms, in which he suggests having incentives and processes in place to motivate employees to share knowledge and to organize more employees to develop cross-functional knowledge. However, these studies have analyzed either formal or informal mechanisms to integrate knowledge (not both), while previous literature has strongly focused on a managerial (deliberate) perspective, giving insufficient attention to the practice-based emergent nature of knowledge (Blackler, 1995; Brown & Duguid, 2001; Van den Hooff & Huysman, 2009). The aim of my study is therefore to explore which factors influence knowledge-integration processes. Noticing that the nature of the knowledge involved in integration processes between R&D units is merely know-how based and situated in people, tools and practice (Argote, McEvily & Reagans, 2003), I pay more attention to the practice-oriented nature of knowledge.

2.3. Methods

2.3.1. Research design

Since I aim to develop theory and since research on integration processes with regard to dispersed R&D activities is relatively new, I rely on semi-structured, in-depth interviews. These allow for the collection of differing perspectives on the topic assessed and allows exploration of the how question of knowledge-integration processes—something which cannot be achieved through quantitative studies (Eisenhardt & Graebner, 2007; Shah & Corley, 2006; Yin, 2008).

2.3.2. Data collection

I collected data from MNCs with several offshore R&D affiliates. Most of these organizations had their headquarters in the Netherlands and had R&D affiliates in Europe, the USA and Asia. I conducted 12 semi-structured interviews with managers and key informants (see also Kumar, Stern & Anderson, 1993) who were directly involved with dispersed R&D in four organizations. The interviews were semi-structured and conducted along the lines of a pre-developed interview protocol (see Appendix A). Hitherto, I have conducted 12 interviews with representatives of 3
organizations that are developing global R&D networks. Table 2.1 presents an overview of the characteristics of these interviewees and their organizations.

Starting with a general interview protocol for the first interviews, the semi-structured interview protocol evolved during the data-collection period and was refined with more-focused questions. The general interview protocol contained only questions regarding the position of the interviewee, his or her history in the company, descriptions of a typical working day, characteristic of the relationships between units, and important learning moments in working with geographically distributed R&D units. Once a general overview of the situations of the interviewees was formed, the protocol became more focused, with questions regarding, for example, specialization, integration, and collaboration and communication between units.

### Table 2.1: Overview of organizations and interviewees

<table>
<thead>
<tr>
<th>Company A</th>
<th>Company profile</th>
<th>Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 20,000 employees</td>
<td>R&amp;D Director</td>
</tr>
<tr>
<td></td>
<td>R&amp;D units in, e.g., the Netherlands*, Germany, France, Canada, Romania</td>
<td>Integration Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information Manager</td>
</tr>
<tr>
<td>Company B</td>
<td>&gt;100,000 employees</td>
<td>R&amp;D Director</td>
</tr>
<tr>
<td></td>
<td>R&amp;D units in, e.g., the Netherlands*, China, USA, England</td>
<td>Vice-President</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Senior Vice-President</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scientist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Department Manager</td>
</tr>
<tr>
<td>Company C</td>
<td>&gt; 10,000 employees</td>
<td>R&amp;D Director</td>
</tr>
<tr>
<td></td>
<td>R&amp;D units in, e.g., the Netherlands*, India, USA, Poland, Australia</td>
<td>Researcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Department Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Department Manager</td>
</tr>
<tr>
<td>Company D</td>
<td>&gt; 100,000 employees</td>
<td>Knowledge Manager</td>
</tr>
<tr>
<td></td>
<td>R&amp;D units in, e.g., the Netherlands*, China, USA, India, Argentina</td>
<td></td>
</tr>
</tbody>
</table>

*R&D headquarters

The interviews, which took 75 minutes on average, were fully transcribed and coded in Atlas.ti. Interpretations made by the researcher of the meanings and stories told by the interviewee were discussed during the interviews, thus leading to mutual understanding, which enhanced the quality of further levels of interpretation (Kvale, 1989).
2.3.3. **Data analysis**

Transcription was undertaken soon after each interview, and each interview was separately reiterated during the transcription process, thus offering an understanding of the interviewees’ thoughts as well as a grasp of the organization’s characteristics. During this process, concepts and constructs were identified and discussed by the researchers involved in the study. Possible constructs and concepts of factors influencing knowledge specialization and integration were proposed. However, they were kept separate as much as possible from subsequent interviews in order to prevent premature or false conclusions. Figure 2.1 shows a timeline with various interactions during the data analysis that enabled triangulation (internal validation) of the research. Below I describe the steps followed in the study’s coding process. Appendix B provides a comprehensive coding scheme resulting from the coding process.
Figure 2.1 Interactions during data analysis
After transcription, the interviews were segmented and coded with Atlas.ti. The coding process was performed in five stages. The first stage involved the open coding of each interview, i.e., each part of text in an interview was labelled with the name(s) of a subject or issue discussed. For example, if an interviewee mentioned the importance of face-to-face contact, the label ‘face-to-face importance’ was assigned to that part of the text. In the first stage, about 35 different codes that occurred in at least two interviews and on average in four interviews were generated. These codes represented categories that were either connected to the questions (such as if and how to collaborate with other units), or that were raised by the interviewees themselves (such as ‘us vs. them’ issues within the firm).

The second stage of the analysis consisted of running a text-search function in Atlas.ti, where several different names for the same category were checked for a code. An example of such a search is ‘specialist knowledge’, where the words ‘know-how’ or ‘experience’ were also used to describe the same kind of concept. The word ‘understanding’ in particular resulted in many hits that eventually counted for a broad description and valuation of mutual understanding, which in turn appeared to be very valuable.

The third stage of data analysis consisted of breaking down the categories formed in stage one into subcategories, thereby making them more concrete. For example, the category “different ways of working” was broken down into different subcategories such as “formal structure” and “communication behavior”, as well as different opinions and distinctly perceived consequences of these concepts. In the fourth stage of the analysis, a network view of the different codes and their linkages was prepared. The relations created in this stage emerged directly from relationships and links explicitly discussed in the interviews. For example, in many interviews the labels “us vs. them” and “building relationships” were explicitly mentioned as being related, so we included this relationship in the network view.

In the fifth analysis stage, the concepts of 'dominant logics', “cultural awareness”, “similarity in knowledge bases”, “knowledge embeddedness”, “structural embeddedness' and “relational embeddedness” were introduced in a side network, since these concepts cover a variety of labels and sub labels. Concepts were also categorized on a unit, knowledge or relational level (Argote et al, 2003). These different codes are displayed in their context as explained by the respondents, without drawing conclusions from a priori theory.
2.4. Findings

I identified several factors that influence knowledge integration between R&D units and their underlying mechanisms, which in accordance with the framework for analyzing knowledge management research of Argote et al. (2003) can be distinguished by three variables: unit level, knowledge level, and relationship level. Table 2.2 provides an overview. The findings illustrate such factors and coping strategies in relation to the tension between specialization and integration processes.

Table 2.2. Summary of concepts

<table>
<thead>
<tr>
<th>Concepts (and definition)</th>
<th>Sub concepts (and definition)</th>
<th>Exemplary quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant logics</td>
<td>Belief structures and frames of reference (Bettis &amp; Prahalad, 1995)</td>
<td>“We have to understand how our actions can trigger certain behavior of our colleagues overseas, how they think, and overseas they should be able to do the same with us.”</td>
</tr>
<tr>
<td></td>
<td>Ways of working in terms of hierarchy, policies, compensation structure, and communication patterns</td>
<td>“…they are also expecting that those things should be done in the same way by the other people in different parts of the world. And in different parts of the world, we have some different way to do those things.”</td>
</tr>
<tr>
<td>Cultural awareness</td>
<td>Cultural norms and beliefs a unit or group espouses</td>
<td>“The unit and local cultures are different there, which is something we should pay attention to. It is all about understanding each other.”</td>
</tr>
<tr>
<td><strong>Knowledge level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similarity in knowledge base</td>
<td>Knowledge possessed by employees</td>
<td>“At headquarters we have decades of experience and learning in our technologies. In India we have enough new scientists, but no experience. This excellence is difficult to transfer.”</td>
</tr>
<tr>
<td>Knowledge embeddedness</td>
<td>Common knowledge Knowledge that is embedded in a shared context which is understandable for both units</td>
<td>“Formal technical know-how is comparable.”</td>
</tr>
<tr>
<td></td>
<td>Local knowledge Knowledge embedded in one unit which is difficult to integrate because of differing contexts</td>
<td>“We use our market knowledge to develop many concepts, which can be difficult to understand for non-locals.” “What we know here is a collection of years and years of work.” “Local policies influence how and what we communicate around here.”</td>
</tr>
<tr>
<td><strong>Relationship level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural</td>
<td>Cohesion Bonding</td>
<td>“One thing we did, we deliberately chose to structure different hierarchical lines back and forth between...”</td>
</tr>
</tbody>
</table>
**embeddedness**  | between units | units.”
---|---|---
**Relational embeddedness**  | **Trust**  Believing that employees in another unit can be trusted with their work in a project  | “…and you should have some trust, sharing your documents, others will look into it.”
| **Identity**  The extent to which units in a relation form a shared identity  | “Especially the us-them thoughts we try to nip in the bud.”
| **Face to face contact**  The ability to communicate and work face to face  | “Well, maybe not even that you actually have to meet face to face with everybody separately, I think it is important that you’ve been there at their work place for more than one day.”

### 2.4.1. Specialization and integration in dispersed R&D settings

From a specialization perspective, interviewees explain that, especially during start-up, a new R&D unit is likely to require considerable guidance and time to develop specific knowledge about the organization’s products and processes. Its knowledge base in a particular field starts to supersede the knowledge from other units on a specific topic, *i.e.*, it develops into a center of excellence. Compared to how R&D structures in the organizations studied were originally centralized in the organization’s home country, R&D units face more-complex relationships when new decentralized structures are introduced, as is illustrated by the following statement:

> “Before the internationalization of our R&D I could say: ‘We are on top of the world.’ That was our attitude. But now you can see that part of our R&D work is done elsewhere. Here people still believe other units should work according to how we work. Many do not see that we can learn from them and use their input.” (Manager in the Netherlands, company A)

When differentiated centers of excellence start collaborating in multisite projects, they face collaboration difficulties. The findings reveal a tension emerging between, on the one hand, the need for specialization in different units and, on the other, the need for linking knowledge of different specializations in order to benefit from those resources of the organization that reside in other locations. In other words, this means that part of the development process of an R&D unit happens elsewhere and that centers of excellence of an organization are scattered over distant
areas, while at the same time, for integration to take place, the organization needs to establish links between these different centers of excellence.

Knowledge integration in the R&D network is commonly realized in projects with specialists of different R&D units. Interviewees point to how their organization concurrently stimulates knowledge integration in projects, and at the same time, promotes specialization within units. Differences between units increase when R&D is dispersed, compared to the original situation in which R&D was organized more centrally within the corporate organization. Consequently, integrating knowledge from different units becomes more challenging, and requires more management attention. The following quotes illustrate the need for knowledge integration between R&D units:

“I think 80 per cent of our projects involve people from different locations. This means that the project manager can be located here, the R&D guy can be located in Bangalore, and the marketing manager can be located in the United States. That is quite usual.” (R&D director in the Netherlands, company B)

“Our program management has an overview of all projects within our R&D. From this we discuss and request developed competences or technologies from other locations that we would like to apply in our project.” (R&D Department head in China, Company C)

By exploring the process of knowledge integration between R&D units, I could identify several factors influencing knowledge integration, consistent with prior work. First, at the unit level, interviewees appeared very much aware of the influence of a unit’s dominant logic and culture on the knowledge-integration process between different R&D units. Second, at the knowledge level, similarity between knowledge bases positively influences knowledge integration. Furthermore, knowledge embedded in a common context makes it easier to understand knowledge from other specialists. Third, at the relationship level, an adequate intensity of relational embeddedness (mutual trust, identification) is likely to provide shared understanding between units. Relational embeddedness in turn is facilitated by structural embeddedness (see Figure 2.1).
2.4.2. Specialized units

Dominant logics

More than half of the interviewees indicated that each unit supposes its own *dominant logic* to be the starting point of how collaboration should take place, not only in the start-up of collaboration between units, but also in more mature relationships. Dominant logic refers to belief structures and frames of reference, and the interpretation of how work should be done (Bettis & Prahalad, 1995). Consider the following illustrative example of one of the cases in this study: an R&D unit of a large multinational organization has thus far always been located centrally in one country, close to the headquarters. All of the 50 or so specialists and engineers of the unit worked together in one building, and all of them had known each other for years. They worked in the same organizational structure, which was informal, and familiar and quite comfortable for most of them. The way they worked, the daily routines, were supposed to be the right way to do the job. The organization then decided to expand the R&D function, and with the help of two expats it started up a new unit in India. There, 10 Indian specialists were hired to virtually collaborate in
projects with the team in the organization’s home country. The new unit developed its own structure, rules and compensation policies, which merely emerged from Indian standards. The organization decided to develop some concepts in multisite projects, so that insights could be shared and concepts could be developed that represented the best of both worlds. Both teams would be given training, communication lines were set up, and collaboration could start. However, this is not what happened. Instead, many employees of the original unit failed to understand the value of the collaboration. They felt that suddenly they had to work with strangers, who knew nothing about the company, or about how things were done previously. The Indians exhibited different ways of working and spoke a different kind of English. Employees of the original unit did not believe that the extra effort they had to put into the relationship would benefit them in their work. This situation caused boundaries to emerge between the two groups. One specialist recalled: “This has a bit to do with our culture. We are real rowdies, you know. We often think, ‘Oh, let them anticipate how we work, not the other way around.’” The following quote further illustrates the influence of dominant logics on the shared understanding between units:

“Nothing right and nothing wrong, because people who are doing one activity, they thought that this is the only way to do this, and this is right. And they were working for a number of years. Now, a person with that status of knowledge will really have a hard time if another person comes and then says ‘Hey, what you are doing is not right in the present scenario.’” Sometimes it is very difficult to believe that, because we believe that what we do is the only thing that is right. It’s human nature.” (R&D Manager in India, company C)

Besides a unit’s own dominant logic, awareness of dominant logics of other units is found to support shared understanding. If units get more involved with each other’s dominant logic, they become more likely to interact with each other:

“Success of multisite projects depends on how well we do this together. We do have the technical expertise. Results will come when involvement is there, not the other way around.” (R&D Department head in China, company B)
“… and it will demand a huge change in our mentality, because we have to learn to be aware that specialists in that unit know more from some concepts than we do.”

(Information manager in the Netherlands, Company A)

Interviewees explain how a significant sub concept of dominant logics, differences in ways of working, can negatively influence the knowledge-integration process. Interviewees recall compensation policies, time-to-market and hierarchical structure as factors that contribute to differences in the way R&D units function. When collaboration between units takes place, these differences require attention:

“In the European unit, people make a plan for a year and then stick to the plan… more traditional. It is relatively stable, and when you have good ideas, you can experiment with these. But in Shanghai you don’t have such kind of free time. Our time to market differs. We define a project with high pressure, deliverables, we manage changes, you even see changes every day. Then you have to adapt and adjust your plan. So you see the communication can be problematic because of different situations.” (Technical specialist, Company B)

Interviewees explain how their former R&D network (one location) in the past did not demand a higher level of formalization, because informal structures were satisfactory. After starting up foreign R&D labs, informal structures are often lacking, and much of the misunderstanding between R&D units is avoided by a higher level of formalization of ways of working and responsibilities:

“A certain transparency in our project management was something we lacked. That’s something we were confronted with when we started working with the Asians. That is how they work, very structured, focused on progress. We’ve experienced all kinds of conflicts, actually, because our way of working was not structured. That was five years ago. In the meantime we made up for lost ground.” (R&D Integration manager, Company A)
Cultural awareness

Interviewees pointed at the importance of cultural awareness, or the ability to recognize how the behavior of others can be influenced by culture. According to the interviewees, differences in culture have caused several instances of miscommunication and misunderstanding between units:

“In order to collaborate, it is important to be able to understand each other. This is not just about understanding technical knowledge; it is all about awareness of each other’s culture.” (R&D Department head in China, company B)

Differences in culture can also become evident, for example, in hierarchical structures, ways of working, and communication patterns:

“The people there always say: yes, yes, yes, while they actually mean no, no, no. Their feelings for hierarchy and compensation policies are different from what we are used to. Now we know, but before, this brought about a lot of miscommunication, and with that irritation.” (R&D Director, Company C)

In addition, interviewees explain how they learn to enhance their awareness of differences in culture. Cultural awareness is stimulated by management through, for example, meetings and courses on culture. However, most awareness develops during daily practice.

2.4.3. A knowledge perspective

Knowledge embeddedness

Knowledge embeddedness refers to how and where knowledge is situated, e.g., in people, technologies and specific contexts (practice), and there’s an assumption that knowledge integration is more likely to benefit from embedded knowledge when it is embedded at both the unit and the relationship levels. This means knowledge should be embedded in a specific unit, but at the same time that relevant knowledge should be embedded in a shared context so that people from both units can understand and tap into that knowledge. The concept can be illustrated by an anecdote that was told by a manager of an R&D unit in China. He explained that, for a Dutch specialist who has worked for the company for more than 25 years, half a page of requirements is
usually perceived as sufficient information to design a new concept. The remaining requirements, which could fill as much as three books, were all in his head. He just knew what was being asked and what to do. This way of working was routine for everyone, and whenever there were requirements that needed clarity, specialists just stopped by each other’s offices. This all changed when multisite projects with the Chinese were introduced. The Chinese specialists possessed formal technical knowledge and they often had experience in the same industry. However, they did not have in their heads the specifics of three books of requirements needed to deliver the same concepts. A complete set of requirements should have been communicated, but in practice this was not the case. The result: the Chinese received a list of requirements and started to work on them, without asking questions. After a few weeks, they proudly presented the concept they had developed, which contained the communicated requirements but had hardly anything in common with what the Dutch had expected them to deliver. The manager reported: “Their ideas were criticized mercilessly, and so was their specialist knowledge.”

The embeddedness of knowledge in a shared context facilitates the creation of common ground between units, whereas this becomes more difficult in proportion as knowledge becomes more and more locally embedded. In the case of R&D work in particular, where knowledge can be quite tacit and is often embedded in people’s experience, creating a context for common practice can be problematic:

“We base our work on what we experience in this field, in our country. If our colleagues overseas do not understand us, this [specific circumstances] is sometimes difficult to be aware of and explain.” (Technical specialist, Company B)

*Similarity between knowledge bases*

Units can recognize and value the knowledge held by other units only if there is some kind of overlap between the units in terms of the basic knowledge each has. This is referred to as *similarity between knowledge bases*. My analysis of the data indicates that, in most cases, there is sufficient overlap between specialists in terms of the scientific, technical and academic knowledge they hold. This means that specialists of different units can understand each other at the basic level of technical requirements:
“It is different [the knowledge bases that units have]. But purely from a technical viewpoint, I don’t see the big difference.” (R&D Director in the Netherlands, Company A)

For knowledge integration to take place—for example, to situate part of an R&D unit overseas where the unit has better opportunities to develop highly specialized knowledge—the common way to transfer specialist knowledge is to station experienced specialists in the new unit and to station specialists from the new unit in the experienced units for an extended period. This allows close collaboration, and creates the opportunity to build a shared context:

“We have two Dutch specialists stationed there, and two Chinese specialists here, and they will stay for at least six months. This is the only way we are able to transfer our expertise.” (R&D Director in the Netherlands, Company C)

However, if knowledge is too deeply embedded in a shared context, parties are not able to learn from each other because knowledge is overlapping. Some interviewees emphasize the importance of having a shared knowledge base, but also argue that it is important to do work separately. They note that a certain amount of competition in these separate projects is vital for the R&D function in general:

“Some things you have to do at two, sometimes at three places. And then you discover, wow, the other guys actually developed an incredibly good lamp (LED). This triggers everyone to understand how they developed it and how you can learn from them.” (R&D Director in China, Company B)

2.4.4. Relations in the R&D network

Relational embeddedness

The factor found to significantly influence knowledge integration between units on a relational level is relational embeddedness, referring to the quality and depth of relationships between units. From the interviews, it becomes clear that direct cohesive ties between units work as a mechanism for gaining valuable information and knowledge, and that they facilitate integrating
knowledge from other units. A manager working in Singapore told us about a situation when 10 specialists from 2 different units started working together in a project on a color printing device. A formal communication structure was set up, and tasks were divided, but that was not enough to make the team collaborate. People from one unit did not know the specialists from the other unit, and did not feel they could trust the others with their work. The specialists were organized as one team, but most of the time they worked as two separate groups. Whenever the two groups came together to discuss progress, which was only once in 2 months, problems emerged because the results of the work of both units were too different to fit together. Management acknowledged the problem and forced formal agreements and contact hours, but an “us vs. them” feeling in the team left tensions between specialists from the two locations. Only after some of the project specialists visited the other unit and met other project members face to face, did all the specialists start to build mutual trust and value each other’s work. This slowly triggered more emergent and spontaneous collaboration, which was necessary to successfully conclude the project. One manager recalled: “You should put specialists together and keep the communication lines short. They get to know and understand each other. Sometimes it is best if they can be put together in one room. If this is not possible, because the project is dispersed over different locations, at least place these specialists in one team with direct contact between them.”

Almost all interviewees referred to the importance of getting familiar with “the other side” in order to understand each other. Building such relationships facilitates mutual trust, identification and cohesion between units, which is necessary to reach an adequate level of shared understanding. If there is a lack of strong relationships, which can especially be the case in an R&D unit’s start-up phase, units are less likely to develop a shared understanding and, in turn, find it difficult to learn from each other:

“We intentionally posted one of our Dutch specialists in Singapore for a period to improve collaboration, because he had difficulty coping with the distant relationship. This measure has helped enormously.” (Integration manager in China, company A)
**Structural embeddedness**

Getting to know each other and building a relationship can be accomplished by visiting the other R&D site, meeting the other team members, and taking part in multisite projects and events. I refer to the process of structuring and coordinating relationships between units as *structural embeddedness*, assuming that structural embeddedness in turn facilitates the development of relational embeddedness by providing a sound foundation for the development of relationships between units. Creating relational embeddedness by facilitating structural embeddedness becomes more difficult if units are dispersed over different continents, but it is nevertheless seen as a prerequisite for collaboration in multisite projects. The following statement illustrates this:

> “You need to sit around the table with each other. This doesn’t work by phone. It all becomes more and more global. This means traveling budgets. If you skimp on these budgets, you burn your own fingers.” (R&D director in China, company B)

In addition to creating strong relationships, units should also enhance their weak ties with other units, because such ties are vital for the development of different knowledge sets and require less trust, identification and cohesion. Findings reveal that units are likely to benefit from each other’s knowledge by creating a kind of optimal strength through the embeddedness of their relationships. Taking structural and relational embeddedness to its extremes can cause either a lack of understanding because the units’ knowledge bases are too diverse, or few contributions to new knowledge because the knowledge the units have is too related:

> “For me, once in a while, face-to-face contact is always good, but when people who are interesting to work with have already met face to face once or twice, then I think it is not necessary to meet again and again in order to get certain things done.” (R&D Manager in India, Company C)

**2.5. Discussion**

In this chapter, I have explored which factors have a significant influence on the integration of dispersed R&D units. A lot of research on the integration of knowledge is characterized by a focus on the managerial perspective (*e.g.*, Puranam, 2009; Hansen & Birkinshaw, 2007; Song &
Shin, 2008), in which it is assumed that integration can be achieved by management interventions of appropriate organizational and technical infrastructures (Van den Hooff & Huysman, 2009). However, this view ignores the complementarity that praxis and practices can have on knowledge integration, as suggested by the practice-based (emergent) perspective. This view, which assumes that knowledge is embedded in practice and is something people “do” rather than “have,” observes knowledge integration as a process which is socially constructed between sender and receiver and which is difficult to manage top-down (Blackler, 1995; Hislop 2009). In this study, a combination of insights from both a managerial perspective and a practice-based perspective is found to be effective in coping with the delicate balance between knowledge integration and specialization. Combining these perspectives in a unit, knowledge and relationship level (Argote et al, 2003) produces several new insights.

First, at the level of the units involved, I have found that dominant logics and cultural awareness, which are interrelated, influence the integration process. Dominant logics comprise a fundamental aspect of organizational intelligence (Bettis & Prahalad, 1995), and my analysis shows that differences in these logics negatively influence knowledge integration between units, thus constraining the ability to learn from other R&D units. I show that coping mechanisms are found in managerial-perspective interventions such as formalization and bridging diverse ways of working. Even if we take into account the literature on dominant logics (e.g., Grant, 1988; Ramanujam & Varadarajan, 1989; Prahalad & Bettis, 1986), little is known about what actions organizations can undertake to effectively manage dominant logics within units or organizations. In order for a unit to be receptive towards the dominant logics of other units, or new knowledge in general, it has to “unlearn” some or all of its own dominant logics. Bettis and Prahalad (1995) suggest that, since changes in structure and systems are strongly related to dominant logics, they are likely to facilitate this process of unlearning. Alternatively, overcoming cultural differences and creating cultural awareness, established in actual immersion in shared practices, helps develop understanding of others’ tacit assumptions (Hislop, 2009). Thus, coping with this factor relies more on an emergent management approach towards knowledge than on any deliberate managerial interventions. Awareness of another unit’s culture creates understanding of the behavior and actions of members of that unit. Although the notions of cultural awareness and dominant logics are not new in studies on dispersed R&D settings (e.g., Verbeke 2010; Lane &
Lubatkin, 1998), the dual way to manage these processes does shed new light on the concepts, by adding insights into different approaches to cope with these factors.

Second, at the level of the knowledge being created and shared, I found similarities between knowledge bases and the embeddedness of knowledge to influence the knowledge-integration process. The purpose of dispersed R&D, knowledge specialization, is likely to negatively influence the emergence of a shared knowledge base, because the experience of specialists is developed in separate contexts. Following Simonin (1997), my findings suggest that, if know-how is developed in a shared context, R&D units develop the ability to understand and adopt proper procedures and mechanisms for integration. This is supported by literature on a KBV of the firm (Grant, 1996a) in which the value of joint know-how has long been recognized as essential for the integration of both tacit and explicit knowledge. Interestingly, while similarity between knowledge bases is first and foremost reached by managerial approaches such as relocation of specialists, the embeddedness of knowledge in a local or shared context is more likely to be developed by specialization and daily practices in multisite projects. From a practice-based perspective, a characteristic of knowledge embedded in a local context is that specialists outside this local context find it difficult to appropriate this knowledge. Moreover, because knowledge is embedded, and in its local context is gradually taken for granted, specialists often cannot value it or articulate it to specialists of other units (Sole & Edmondson, 2002). The literature on knowledge embeddedness (e.g., Sole & Edmondson, 2002; Brown & Duguid, 2001; Cummings & Teng, 2003) recommends practice-based approaches such as mutual engagement in activities and forms of communities of practice as ways to create a shared repertoire, so that knowledge can be created and embedded in a shared context. This study adds to the literature on embeddedness by illustrating that working together in the context of multisite projects not only identifies differences between units, but in time also provides the basis for building common ground in which knowledge can be embedded and can, in turn, be recognized by specialists regardless of their local context.

Third, at the level of the relationship between the units involved, the data indicates that the structural and relational embeddedness of units significantly influence knowledge integration. Again, from a managerial and practice-based perspective, there is a distinction between coping
mechanisms. The development of structural embeddedness between units, which can be organized by cross-unit responsibilities and direct communication lines, for instance, is primarily achieved by a top-down managerial approach. Creating relational embeddedness nevertheless requires a more practice-based approach in which specialists become familiar with each other and each other’s practices through work visits and face-to-face contact. Considering the relatively tacit nature of specialist knowledge and the dispersedness of R&D units, the distribution of R&D is found to negatively influence actual collaboration in multisite projects. Knowledge integration is a process of knowledge sharing and learning, facilitated by immersion in shared practices and intensive information exchange, and more likely to occur in highly embedded relationships (Uzzi, 1996; Hansen, 1999; Hislop, 2009). Establishing such relationships takes time but is nevertheless necessary to create trust, a shared identity and cohesion between and among units. These findings are consistent with other research on global R&D networks. For example, Dhanaraj, Lyles, Steensma & Tihanyi (2004), in their study of dynamics in tacit and explicit learning in an international context, found that relational embeddedness has a positive impact on the transfer of tacit knowledge.

Furthermore, our findings illustrate the tension between specialization and integration in several ways. For example, results illustrate the notion that the specialization of units itself is likely to inhibit knowledge integration, because, for specialization to take place, a unit requires a certain degree of autonomy to develop its own knowledge, which is likely to cause differences between units. This, as described above, limits a unit’s ability to access knowledge held by other units, to recognize, link and create new knowledge from combining its own specialism with that of other (internal) R&D units (see, for example, Singh, 2008). Accordingly, the integration of knowledge between dispersed R&D units is possible only if a sufficient level of relative absorptive capacity exists on both sides. My findings show that all factors identified strongly influence the ability of one R&D unit to value and absorb knowledge held by other units. This is in line with, and extends, Lane and Lubatkin's (1998) work on relative absorptive capacity, in which they found that “the ability of a unit to learn from another unit is jointly determined by the relative characteristics of the two units, denoting similarities in ‘know-what’ (knowledge), ‘know-how’ (knowledge processing systems), and ‘know-why’ (dominant logics)” (Lane & Lubatkin, 1998:473). This study adds factors of embeddedness to their model, thus providing a
holistic model. In line with Lane and Lubatkin (1998), it also extends the concept of absolute absorptive capacity (Cohen & Levinthal, 1989), which is conceptualized as the ability of a unit to value, assimilate, and apply new external knowledge. This concept does not take into consideration the fact that units differ in their capacity to learn from other units. My findings suggest that an overlap between characteristics of different units probably encourages shared understanding and, in turn, the integration of knowledge from across these units.

Elaborating on the above, practical implications can, first of all, be found in the different interrelated factors that influence collaboration and integration between geographically dispersed R&D units. Second, knowledge-integration processes benefit from the complementary view of using deliberate and more-emergent approaches, which indicates that a combination of the two is favorable for knowledge integration. Specifically, when managing the relation between different R&D units with the aim of combining the knowledge held by these units, managers should be aware not only of their manageable courses of action, but also of complementary self-organizing processes that emerge and exist in the social context of practice for which they can provide a fruitful context but which they cannot influence directly (Van den Hooff & Huysman, 2009). Such self-organizing processes are not thoroughly unpacked in this study (because of the fact that most interviewees were managers and not engineers), but will be elaborated in chapter 4.

In conclusion, I would emphasize that earlier work on knowledge integration in the context of dispersed R&D settings has underappreciated both the essential effect that practice-based approaches can have on knowledge-integration processes, and how a thoughtful balance between deliberate and emergent approaches can help understand and overcome integration problems. In the next chapter I take this notion into account, and report on a case study of a dispersed collaboration between two engineering teams working on graphical-display technology. By taking a practice-oriented view of the case, the study addresses the complexity of embeddedness in practice.
Collaboration between dispersed R&D units on new product-development initiatives requires collaboration tools and a shared context. New joint fields are created to shape such a shared context. This chapter discusses how boundary objects, which are crucial for collaboration in dispersed settings, can play different roles in facilitating such a new joint field. Case-study data from a large R&D project involving two geographically dispersed R&D units illustrate how the local embeddedness of boundary objects—in this case 3D CAD software and wikis—can have a strong influence on their functioning within new joint fields in dispersed R&D collaboration projects. Our findings show that, while both boundary objects share important design functions and thus could play a crucial role in the collaboration, only the wiki was successfully exploited as a technological boundary object. This study contributes to the literature on boundary objects in dispersed R&D collaborations, and to the development of the concept of new joint fields.
3.1. Introduction

Organizations that perform R&D projects in geographically dispersed settings often encounter differences between units in terms of how they operate and address problem-solving and innovation. Although dispersed R&D is seen as an opportunity to encourage innovation and new knowledge assets, its contribution to the organization’s innovative capability is found to depend on integration efforts, such as realizing absorptive capacity (e.g., Cohen & Levinthal, 1990) and intra-organizational links (e.g., Lahiri, 2011), which are complex dynamic capabilities that require considerable attention (Easterby-Smith & Prieto, 2008; Helfat, 1997; Zollo & Winter, 2002).

To establish integration in geographically dispersed settings, boundary objects can be fundamental tools to facilitate communication, understanding, and collaboration (Carlile, 2002; Star & Griesemer, 1989). From a practice perspective, boundary objects refer to artifacts that are understood in their local setting yet have enough common ground to facilitate the shared practice context in dispersed settings. Examples of boundary objects include graphs, designs, documents, intranets, and other entities that can link actors together to allow for collaboration even if full consensus has not been reached on the object (Bechky, 2003; Wenger, 1998). Although the main objective of using boundary objects is to span boundaries between actors from different fields, this objective is often not realized. In this study, I seek to explain this phenomenon by focusing on the role of boundary objects in realizing collaboration in dispersed R&D settings, and by explaining how the local embeddedness and the history of these objects can influence the role that boundary objects play in new joint fields.

Previous research describes the creation of a new joint field as a prerequisite for new-product development to take place (Bourdieu, 1996; Carlile, 2004; Levina & Vaast, 2005). A new joint field functions as a context in which newly formed groups can build and share their practice. Examples of new joint fields are a new project environment, the establishment of a virtual R&D unit, or determining boundaries for a new joint study involving engineers from dispersed R&D initiatives. In light of this new joint field, or shared practice context, boundary objects seem to be impartial, neutral artifacts that become part of the field in order to link people and practice. This conceptualization of boundary objects, however, ignores the historical path they might have taken.
before they were assigned to their new fields. Boundary objects can be wholly or partly adopted from, and originally rooted in, existing local fields, and subject to local routines and practices (Bechky, 2003; Pentland & Feldman, 2005; Knorr, 2001). In local settings, this embeddedness of boundary objects has been found to facilitate group effort, as these objects become adapted to the local context that specialists work in (Star, 2010). However, in non-local settings in which different groups plan to work together, such local embeddedness can become counterproductive.

In line with this dissertation, the general research question guiding this study is, “How does knowledge integration take place when R&D units collaborate?” As it turned out that boundary objects play such a crucial role in dispersed collaborations, they became the focus of this study. Previous work on boundary objects has tended to ignore the influence of the “local embeddedness” of a boundary object on its functioning in a new joint setting, while such embeddedness can affect how a boundary object is perceived in a different context. In this study, I analyze the influence that locally embedded boundary objects can have on the development of a “new joint field” in dispersed R&D settings. In particular, this study focuses on what influence a boundary object’s history has within a particular practice context (i.e., a specific local R&D unit) on its functioning as a boundary object within a newly established shared practice context (i.e., the context of a practice that is shared between two or more dispersed R&D units).

The basis of my analysis is a case study of a collaboration effort between a Canadian and a Dutch R&D department in an MNC specialized in print technologies. Based on an analysis of data from 33 face-to-face interviews, and of literature on new joint fields, boundary objects, and routines, we show that, while both 3D-CAD software and wikis as boundary objects share important design functions and that they could thus play a crucial role in the collaboration, only the wiki was successfully exploited as a technological boundary object. On the basis of this analysis, I have been able to make two main contributions. First, I consider boundary objects as elements of new joint fields and show that the historical use of boundary objects with similar functions in local settings can play a key role in the adoption of boundary objects in new joint settings by different groups. Second, I argue that the history and local embeddedness of boundary objects can lead to dispersed R&D workers’ having a biased perception of these objects, and that
an awareness of such a bias allows us to better understand how these boundary objects can affect the creation of a shared practice context in which joint R&D projects can take place.

The chapter is organized as follows. I start by introducing the literature on R&D initiatives and explain the importance of developing new joint fields. Next, I discuss literature on boundary objects and relate this to literature on routines to illustrate the phenomenon of the embeddedness of boundary objects in practice. I then use my case study to illustrate two examples of the use of boundary objects, and elaborate how these boundary objects did or did not become part of this joint project. I conclude with the implications that my analysis offers for the understanding of introducing boundary objects in new joint fields.

3.2. Theoretical background

3.2.1. New joint fields

The concept of a new joint field was introduced by Bourdieu and Wacquant (1992) and elaborated on by Levina and Vaast (2005) to describe how the creation of a new field within R&D supports boundary-spanning efforts between different fields of practice. The authors explain that a new joint field allows a new group of actors to differentiate from others who are not participating in the field, to develop a joint interest, (Bourdieu & Wacquant, 1992), and to overcome the embeddedness of practices from other contexts (Orlikowski, 2002). Levina and Vaast (2005) argue that the emergence of a new joint field in which R&D specialists from different contexts meet, such as a new joint study, a new project or a new virtual R&D unit, enables them to create a shared context in which they can expose and share their expertise.

Since new joint fields can facilitate a shared context in which different groups are motivated to participate and contribute, they appear to have a somewhat neutral, impartial character for all actors involved, compared to the different existing fields that actors originally came from. A new joint field can thus be seen as an opportunity to reduce boundaries between actors or groups of actors from different fields. It is created, for example, when geographically dispersed R&D groups are brought together for global collaboration (Bryant, 2006; Hinds &
Mortensen, 2005). This gives actors the ability to jointly negotiate, organize and develop practices and routines, so as to build a collective mind (Weick & Roberts, 1993).

The concept of new joint fields is related to other concepts concerning “shared space” and “shared contexts.” Nonaka and Konno (1998), for instance, introduce the concept of “ba,” which they define as a shared space that serves as a foundation for knowledge creation. In this space, knowledge is embedded in the practices and knowledge assets available, and made use of through human interaction with the elements in this space. They also define it as a platform in which knowledge is embedded and that can be developed into a “collective mind.” This space can be physical (e.g., office, dispersed business space), virtual (e.g., e-mail, teleconference), mental (e.g., shared experience, ideas, ideals), or a combination of them (Nonaka & Konno, 1998 p. 40).

Hinds and Mortensen (2005) focus on the importance of a shared practice context—a context that transcends or connects local practices—in dispersed R&D. In their field study on conflict in dispersed R&D teams, they found that such a shared context lowers the perception of distribution and conflict within dispersed teams, and that both shared identity and shared context have a stronger effect on the establishment of collaboration in distributed teams than in collocated teams. Other studies have considered the influence of a shared practice context on, among other things, information systems (e.g., Roberts, 2000; Schultze & Boland, 2000), CAD systems (e.g., Goodman & Darr, 1998; Leonardi, 2011a), technology and routines (e.g., Leonardi, 2011b), situated knowledge (e.g., Bechky, 2003; Cramton, 2001; Sole & Edmondson, 2002), and organizational knowing (Orlikowski, 2002).

In conclusion, creating a new joint field (which has similarities to shared spaces and shared practice contexts) is likely to facilitate collaboration between dispersed R&D units by facilitating the emergence of joint interest and shared practice between units, and to overcome the locally embedded interests and practices within units. Since these units do not work together physically, they are less likely to have a natural shared practice and social context than teams that are collocated, and this makes the creation of a new joint field crucial in dispersed R&D settings.
3.2.2. Boundary Objects

In dispersed R&D settings, the creation of new joint fields is strongly supported by tools and artifacts such as prototypes and collaborative technologies. These tools and artifacts can be conceptualized as boundary objects that help in the creation of a new joint field that transcends the local practices and interests of particular units.

In collaborative settings, boundary objects are “a sort of arrangement that allows different groups to work together without consensus, and form boundaries between groups through flexibility and shared structure—they are the stuff of action” (Star, 2010, p. 602). Star and Griesemer (1989), and Star (2010), highlight the functionality that they say boundary objects should cover: every object can be a boundary object, but only if it is used between groups to allow for joint action and collaboration. This means that boundary objects need to have a sufficient level of interpretive flexibility (Star & Griesemer, 1989): different groups are able to interpret and use an object in such a way that collaboration is facilitated through this object, either through human interpretation of the actors involved or through the flexibility in the design of the object (Pinch & Bijker, 1984). Examples of boundary objects include documents, programs including IT programs, designs, prototypes, and standardized reporting forms (Carlile 2002; Levina & Vaast, 2005; Star & Griesemer, 1989), narratives (Bartel & Garud, 2003), and processes and methods (Swan, Bresnen, Newell & Robertson, 2007; Nicolini, Mengis & Swan, 2011). Boundary objects are flexible in the sense that they can have different meanings for different groups but still have enough features common to all groups to be recognizable and to be used as means of translation (Star & Griesemer, 1989). The implications of boundary objects for collaboration have been investigated in several studies on knowledge sharing practices (e.g., Schultze & Boland, 2000), information-systems-related work (e.g., Levina & Vaast, 2005), design and manufacturing (e.g., Henderson, 1991; Subrahmanian, Monarch, Konda, Granger, Milliken & Westerberg, 2003), and combinations of these fields of study in distributed environments (e.g., Goodman & Darr, 1998; Newell, Scarbrough & Swan, 2001).
3.2.3. Routines

Especially in dispersed collaborative settings, the deliberate use of boundary objects as a way to communicate and share complex knowledge can be an important part of interactions between groups (Orlikowski, 2002). Boundary objects are seen as objects tailored to and embedded in the needs and arrangements that arise in practice in connection with actual work processes (Star & Griesemer, 1989). The way in which a boundary object forms, appears, and is valued when used, depends on the context in which it is placed from the moment it is first used. Boundary objects embedded within a group can function as a valuable tool for collaboration. Because the group has been involved in its development, such an object is embedded in a practice context, or field, in a way that suits the practice and routines of the group, and that is therefore closely interrelated with the work setting of a group and its competences (Orlikowski, 2002).

Yet when dispersed collaborative settings are initiated, for instance in R&D projects, the embeddedness of a boundary object in its original setting can become problematic. The historical use of a boundary object by different groups in local settings influences how it will be used in a new joint field. In other words, if an object has been developed and used by R&D unit A in its local practices, it may be problematic to use it as a boundary object in a new joint field that consists of a collaborative project with R&D unit B. The situation can become even more complex if different groups use comparable boundary objects that are not sufficiently different from each other, yet not similar enough to match and be embraced by other groups in the new joint field. For example, let’s say one local group has developed its own boundary object, such as a tool specialized to capture changes in their specific technology, and that it then introduces this tool into a collaborative setting without bearing in mind that its tool is fully tailored to the practices and routines that have been developed around its specific work setting. The collaborative setting in which this tool is then introduced involves other actors and different work practices, which thus do not necessarily find the same useful fit with this tool as their counterparts did in the context the tool originated in.

This is where the concept of “routines” comes in. Routines, conceptualized as “repetitive, recognizable patterns of interdependent action, carried out by multiple actors” (Feldman & Pentland, 2003: 95), can be seen as the mechanisms that tie boundary objects to practice and to
human actors. In time, and through interactions with human action and practice, boundary objects are given meaning, support shared understanding within a group (Feldman, 2000; Weick & Roberts 1993), and become structured and even standardized in work settings over time (Star, 2010). The “path” that boundary objects take in practice embeds them in the routines of the group that develops and uses them. At the same time, this makes it more difficult to decouple them from these routines and to use these objects in other settings (e.g., Schreyögg & Sydow, 2011). Thus, boundary objects are tightly coupled with practice and therefore not easily transferable across distinct practices and groups.

Hence, there is a paradox in the interpretive flexibility that can emerge in the use of boundary objects. If boundary objects in practice have the tendency to become embedded in the practices and routines they are supporting, this can have implications for their use in other practice contexts, such as new joint fields. It seems valid to identify boundary objects that are successfully facilitating work in one setting, and to use them in new collaborative fields. However, these new fields will have different practices and routines from those in previous fields. When new actors and new practices are confronted with these boundary objects, there is a possibility that previous characteristics of these boundary objects that made sense in their original setting can become misunderstood. This means that there is a risk that these boundary objects can become less comprehensible to new actors, because they have become somewhat customized through their development in other fields. If these boundary objects are then introduced into a new field, then the actors that have previously worked with them will have a different perception or will attribute a different meaning to them than those actors to whom they are new. Furthermore, and taking into account that these boundary objects will have a different function in a new joint field than they had in their original setting, because the practices and routines around them differ, these boundary objects become “biased” towards different actors. As can be seen in many empirical studies on boundary objects (e.g., Goodman & Darr, 1998; Henderson, 1991; Leonardi, 2011; Levina & Vaast, 2005; Nicolini, Mengis & Swan, 2011; Subrahmanian, Monarch, Konda, Granger, Milliken, Westerberg & the N-Dimgroup, 2003), a bias can have important implications for the introduction of objects in new joint fields. Investigating this perspective is useful because it allows for a better understanding of the consequences that biased boundary objects have for new joint fields, and more specifically for dispersed R&D initiatives.
In what follows I explore this perspective by means of qualitative research. The empirical study that I discussed next demonstrates two examples of boundary objects used in a collaborative project between two geographically dispersed R&D sites. From my analysis I derive insights that help to understand the role that existing routines and biases surrounding boundary objects play in creating new joint fields.

3.3. Methods

3.3.1. Research site

I conducted a case study at an MNC I will call “Graphic” and that specializes primarily in B2B laser and inkjet print technologies. The company has its headquarters in the Netherlands. With 23,000 employees in more than 80 countries, Graphic is one of the largest players in the field of print technologies. The company has about 800 employees working in R&D in the Netherlands, and several smaller R&D sites in Europe, Asia, and North and South America. In the Netherlands, the R&D focus of the organization over the last couple of years has moved towards developing cheaper and more-efficient printers.

In this study, I focus on a niche technology, printing high quality images on various materials, for which the expertise was developed in a Canadian unit of Graphic, which I will call GraphicCA. The Canadian unit was originally acquired about 14 years ago. With about 50 specialists and engineers working in GraphicCA, most of the research on, and most of the design and integration of, graphic-display technologies had been carried out by the Canadians. The print-nozzle technology that was used to make the system that directs the movement of the nozzles, and the software directing the printing process that GraphicCA invented, allow the company’s machines to print on different materials such as glass and plastic. These technologies make the printers functional in different areas, such as art and business, and that has helped make the printers a success story for Graphic.

As is the case with various other organizations of its kind, Graphic’s designers, specialists and engineers work with 3D CAD software to develop its technologies. This software allows them to design in a virtual-3D environment in which drawings can be combined, with all sorts of
calculations and calibrations regarding materials and movement, for example. Not only internal specialists but also test centers, manufacturers and suppliers can look into the designs in order to understand technical specifications. At the time the Canadian unit was acquired by Graphic, it already had its own 3D-CAD format, which was different from that which the Dutch parent company had. Because Graphic did not have any concrete plans for collaboration after the acquisition, GraphicCA remained in a position to continue operating its own 3D-CAD software.

Project Mesa

About 12 years after the acquisition of the Canadian unit, Graphic decided on a collaborative project between GraphicCA and GraphicNL, as I will call it, a group from the R&D department in the Netherlands. Starting in 1999, GraphicNL had designed an automated print table that could lift and move material on the work surface of printers. Around 2007, Graphic realized that it might be useful to integrate the table with GraphicCA’s technology, to allow higher volumes and different kinds of material to be printed without any manual help in lifting and placing material on the table. The combination of both technologies would result in a novel automated printer, and eventually make printing with the machine more cost-effective, as less manpower would be required for a print job. Thus project Mesa was started, and Graphic allocated 20 engineers specialized in the table technology as well as print technology, and the full R&D unit of 50 engineers from GraphicCA, to the project. Management and lead engineers paid several visits overseas to get to know the people and technologies in the various units. Although there were several differences with work in “hometown” projects, such as a time difference of nine hours between the units, and differences between cultures and ways of working, still, the engineers did understand the basics of each other’s technologies, and were thus able to understand and adapt to most design choices their counterparts were suggesting. Formally, collaboration took place through virtual progress meetings that were held either in person or on the phone, as well as the use of e-mail, CAD systems and a wiki that was built especially for the project.

Although many R&D managers and engineers on both sites expected project Mesa to result in a profitable innovation, management canceled the project about two years later. Although still in the design phase, Graphic had already ordered most of the equipment and parts...
required to build the first prototypes. Engineers working on the technology for years were
devastated, because a clear reason for cancellation was not communicated.

3.3.2. Data collection and analysis
Data collection within Graphic became possible a few months after cancellation of project Mesa.
After introductory interviews with 3 managers and 3 lead engineers at GraphicNL, I visited
GraphicCA and conducted semi-structured exploratory interviews with 2 R&D managers, 4 lead
engineers, 12 R&D specialists, and 3 managers and employees from manufacturing and sales. All
27 interviews were conducted face to face and lasted 50 to 90 minutes. Having transcribed them,
typically right after each interview, I went back to the Dutch unit and held 6 more face-to-face
interviews to get a complete picture of the perspectives from both GraphicCA and GraphicNL on
the collaboration.

The choice for studying important boundary objects used in the Mesa project became
clear after the first few interviews. Engineers noticed that it was far more important to use
communication tools to gain and exchange knowledge in an international collaboration effort
than it was in local settings where people could meet face to face, and the tools used for
collaboration came up in every interview. Exploring the role and the use of these boundary
objects soon became one of the themes of the interviews.

The 33 interviews were transcribed and coded with Atlas.ti in several ways. By means of
open coding, different parts of texts were coded with “subject codes” ranging, for example, from
how work procedures were arranged and how they differed across units, to how work was carried
out in practice and how engineers learned from each other. Also, many different stages and
specific activities during project Mesa were coded. Based on the literature concerning dispersed
R&D projects and knowledge-management issues, coding schemes were made for different
theoretical frameworks that emerged from discussing this literature (see appendix A for an
example). One of these frameworks concerned boundary objects and processes or decisions that
had influenced their use, as well as fields and processes (routines) that these boundary objects
were situated in. The coding and analysis were done iteratively with the research team, the
companies, and ongoing checks against theory. Figure 3.1 provides a rough overview of
interactions in which the analysis and data were reviewed. Appendix C provides a simplified but
comprehensive overview of the coding structures. In the next section, this analysis is used to portray boundary objects in their setting in the Mesa project. I use quotes to illustrate my findings and arguments on using boundary objects in dispersed R&D projects.
Figure 3.1 Interactions during data analysis
3.4. Findings

3.4.1. New joint fields and boundary objects at Graphic

In this section, I use two examples to show how boundary objects were used for virtual collaboration between dispersed R&D departments at Graphic. Both examples stem from the same joint project, and were initiated around the same time. The first demonstrates the use of 3D-CAD models as a way to jointly design and develop a virtual prototype. The second demonstrates the use of an online wiki as a way to jointly discuss technology and to retrace technological decision-making. While both boundary objects share important design functions and could thus have played a crucial role in the collaboration, only the wiki was successfully exploited as a boundary object. To illustrate the role that the history and embeddedness of boundary objects in separate fields can have on the creation of new joint fields, both examples are presented in the light of their new joint field, their supposed function as boundary objects, and related routines.

3D-design models

With the start-up of the Mesa project, a new joint field was created between GraphicCA and GraphicNL by allocating people, time, tasks, responsibilities and other resources to the project. Designers, specialists and engineers from both locations were fully appointed to the project; visits by managers and lead engineers and (virtual) meeting schedules were set up. In other words, a field was being created, in which a newly formed group started working on a technology.

3D-CAD software plays an important role in Graphic’s product design and engineering. With this software, specialists and engineers from different fields (software, mechanic, and electro technical groups) can develop their part of a technology within one and the same virtual 3D model, thus facilitating collaboration between dispersed designers and engineers. In the Mesa project, the CAD system played a crucial role in combining two technologies within one product: the Canadian printer on the Dutch automated table. With the system, engineers could look into each other’s designs, make calculations on how different elements react to each other, and use the designs as boundary objects in local and virtual meetings.

Traditionally, GraphicCA worked with a different 3D-CAD format than GraphicNL. The use of different CAD formats within the project resulted in a serious problem: they were not compatible. As a consequence, GraphicCA had to upload their designs into a different format and
send them to GraphicNL. The uploading and downloading of these files resulted in a significant loss of information in the designs, and this had to be made up for by GraphicNL. If GraphicNL changed something in the design in their format, GraphicCA had to adjust it manually in theirs. Moreover, designs could not be shared in 3D but only in static versions. A manager from GraphicNL and a lead mechanical engineer from GraphicCA commented on this:

“Our CAD packages do not go along very well. In the Mesa project, we designed the lower part, to fit on their upper part, with print nozzles on top of that, accurate to the nearest millimeter. And that is extremely precise. You can’t just estimate and try and think it will work, unfortunately…. So if they change something tomorrow, or we change something, then you can start all over. And that is what we did.” (R&D Manager, the Netherlands).

“They use different CAD software than we do. So they can give us the 3D models in a certain format, but they were not… So we could look at them, but that is basically all we could do. And we spent a lot of time looking for a way… some sort of translator. To allow us to use all the work they had done already. None of that worked out really well, so then we had to look at our engineers remodeling everything that they had done based on their designs, which is a bunch of extra work… We had engineers here trying to design the next revision of it, but here they feel very disconnected with the actual project…” (Lead mechanical engineer, Canada).

Next to the information loss resulting from this incompatibility, engineers were not fully aware of the consequences that the changes would have for other parts of the printer. Instead of the CAD system’s being the most important source for collaboration between both locations, it turned out to be a system supporting only limited dispersed teamwork. On top of that, it created frustration and miscommunication between locations, because engineers on both sides had to do a lot of extra work and could not combine efforts to jointly create a new design and technology.

Why did this 3D-CAD system fail to act as a boundary object between Canada and the Netherlands, while locally it was the most important boundary object in both R&D departments? Obviously, the two system formats did not match. But why did management allow both formats
to exist next to each other, instead of choosing either one of the formats? As explained above, both locations had traditionally used their own CAD package for many years. The packages in each unit had become ingrained in work procedures built around the system, and adapted to formal documentation and change releases. Engineers, test centers, manufacturing departments, and suppliers had all been working with their own CAD format for years, and that would make any change in format very costly and complex for all parties involved. Furthermore, GraphicCA had most of the technology they would use for this printer already written in its CAD system, as did GraphicNL with its automated-table technology. In the Netherlands, more than 800 R&D employees and thousands of others involved had integrated the GraphicNL format in their work. Despite many hours of discussion in managerial meetings, a choice to dismiss either one of the formats and start working on the same format in both locations could not be made.

Wiki

Besides the CAD system, work in the Mesa project was supported by the use of a wiki, in which all engineers could upload their reports and documents, participate in discussions, and report, explain and edit released changes. The wiki allowed engineers to share their insights with other engineers involved in the same part of the technology. It allowed engineers to understand why choices in design were made by other disciplines, and in past releases. Used as a boundary object both within and between GraphicCA and GraphicNL, the wiki supported boundary-spanning in several ways. During the design phases of the project, it played an important role in the interface between GraphicCA and GraphicNL. Engineers and technical designers felt the wiki was used as a kind of work platform, on which daily discussions and open access supported a shared understanding between the two locations. It provided the Canadian unit access to technical knowledge residing in the headquarters of Graphic in the Netherlands, which had not been possible before, because of information-security arrangements within the company. With the support of a practical search function, engineers from both sites could trace a considerable amount of documentation on preceding studies of the Mesa project and its separate technologies.

Although the wiki database was not yet fully developed and running during the Mesa project, engineers were using and updating the system on a regular basis. They could learn from
each other’s insights, and if there were questions, they could post them on a separate section for discussion with other engineers involved. A software engineer from the Netherlands used the following example to underscore the importance of the wiki for joint work practices between the two locations with the following example:

“There was, for example, a page on automation. Well, the workflow architect had posted a story there, on how he visualized the project. And with every level of automation, his story linked to a new page with more-detailed knowledge on that level, up till descriptions of design and how to bring the technology into practice. On the most abstract level we have had most discussion, because then you discuss what the customer would like and what not. Often you see that the architect keeps administering the page, and that a discussion forum is attached so others can post their opinions. Eventually the architect reports his final decisions on the design. (…) But if it is something that I do not agree with, I can directly take notice and contact him to offer my help… This is so much more dynamic.” (Software engineer, the Netherlands).

Although the wiki was not a boundary object in the sense that the actual design was available as an artifact that both R&D units could work on, it did function as an object used to adapt to the local needs of the two units, and significantly supported communication between dispersed members of the project. Engineers tried to create shared understanding by studying each other’s past work and offering help in design issues where necessary. Everybody who was using the wiki valued the database as a highly functional tool to translate expert knowledge on a common platform and to bridge location and time differences.

Before and during project Mesa, various other databases were used in local settings in GraphicCA and GraphicNL, but reports on technical studies and previous design issues on the different technological parts were easily transferred to the new wiki environment. Although both locations had their own databases (and discussion platforms) before the joint project was established, this did not seem to cause conflict when setting up the Mesa wiki as a boundary object between the two sites. A mechanical engineer and a software engineer from GraphicCA explained how the engineers in his unit felt about the new environment:
“This is something really recent. Only in the last couple months we started to put stuff on there. So, more and more people are using it. And moving forward, I am going to ask that everybody who generates any sort of study or report makes sure there is a copy on it that is searchable (…). Before we had access to the wiki, we could call for a handful of people we know over there, and ask them if they knew anything about a certain topic or if they could point us to the right person. That was our only sort of access into there. So that only worked if one of these persons knew something about what we wanted.” (Mechanical engineer, Canada)

“…It is kind of evolving. We haven’t exactly figured out what it is going to look like. We are trying things out (…). GraphicNL is also using it for project Mesa. It seemed that they were all kind of new to it too. It is a little informal but easy to use. So there is a lot of content on it already. The wiki is for all the teams, we created sort of our own section. So, I put some basic information on our architecture, which then some of the engineers will break down into their little piece, create links with their information. Anyone can go and change.” (Software engineer, Canada)

When the wiki was introduced as a new environment, users experienced it as part of the new joint field, and their ability and motivation to work with it did not interfere with the way they had stored and discussed their technical knowledge and insights previously. The wiki became an embedded tool in both local settings, while keeping its function as a shared platform on which both locations could collaborate.

Graphic initiated the first large project between the two dispersed units by setting up project Mesa between the R&D units in Canada and the Netherlands. It faced a clear challenge: having two units working together on combining technologies from both sites to develop a new innovative product. Besides mutual visits and virtual meetings, the two examples above include the most important boundary objects for collaboration between the units. However, while the online database formed by a wiki revealed explicit benefits for sharing knowledge and joint innovation between the dispersed groups, the 3D-design model in the CAD system turned out not to be common enough to support a new joint field. Instead, because the functionality derived from this important object created a form of segregation rather than a shared context between its
users, the tool did not fulfill its intended function. Since the 3D design model was such a significant prerequisite for collaboration, and since neither site was able to adapt to another format, not even by developing a translation tool, collaboration stagnated.

3.4.2. Interpretive Flexibility

While both the 3D-CAD system and the wiki could be seen as boundary objects facilitating collaboration in the dispersed setting of the Mesa project, the two examples had different outcomes in terms of interpretive flexibility. The example of the wiki demonstrates that there was sufficient flexibility in the boundary object for it to be shaped as a shared artifact by the various technical groups and dispersed teams. Although the wiki was not the most essential boundary object in the collaboration, it did fulfill several requirements. In contrast, the 3D-CAD did not provide sufficient interpretive flexibility for each of the units to interpret it in a way that would help them align their own practices with the shared practice context. This boundary object was intended to be the essential tool to make dispersed collaboration feasible, but in the event, differing interpretations of the two formats that were used resulted in nothing more than static design views that did not allow users to share their practices. Engineers and designers who depended on the tool did try to interpret the system in different ways, for example by searching for a tool that would translate between the formats, and by working around the differences between the formats and remodeling after every change proposal. However, they did not consider adopting one of design formats and scrapping the other. Neither was switching to an entirely new format an option for either site, as is shown by the following quote, recorded a few months after the project was cancelled:

“Both sites believe it is not their call to change their whole system for this project. (...) We could have made it happen, if they were also convinced, but that would mean that they had to change their genes as an R&D site. That is hard, but it could have been possible. (...) And vice versa as well. But that is not what happened.” (Project team leader, the Netherlands)

This quote illustrates two things. First, it shows the extent of the change that each site would have to have made in its routines and technology tools in order to share the same boundary object in project Mesa. It would result in a local compatibility problem with previously built knowledge in
the CAD system for at least one of the sites. Changing to a different format would have meant that nothing produced in the new format could have been integrated with drawings done and knowledge gained up to that point. Second, no one believed that a format change was a realistic option. Such a change would have resulted in a much larger change within the knowledge structure of at least one unit, and knowledge would have been available in different and mutually incompatible ways, thus decreasing the local interpretive flexibility of knowledge). A few months after the project was cancelled, some managers reconsidered the option of adopting another format, as the example illustrates, but once again no one else was open to this change. The flexibility of the boundary object seemed to be lacking in terms both of the degree of flexibility allowed by the architecture of the object itself, and of how people were able to interpret the object as a shared boundary object.

CAD software was the technique to virtually design and share between engineers. However, Graphic was not able to introduce a substitute for the CAD system, simply because from its standpoint there was no alternative. This system was considered the only means of collaborating efficiently on designs as a shared practice and, even though the CAD system did not meet the requirement of “interpretive flexibility,” it was considered by everyone involved as the most important boundary object in the dispersed project.

3.4.3. Routines and boundary objects

With two different design systems in one virtual collaboration, Graphic faced a clear problem: neither of the two sites was able to understand the other site’s work in its 3D-CAD system, and neither site felt able to adopt the format used by the other R&D site. But what exactly made the two sites so unable or uncompromising on this boundary object that adoption of another format became impossible? Putting this question in the interviews elicited answers describing differences between the two sites, many being related to how the sites developed historically—specifically, how each site had developed its own ways of working and thinking about how to perform R&D, and how the use of its design systems had become embedded as a part of its daily practice. Previous format choices for design tools were based on a favorable fit with working
conditions at the specific unit and local requirements it had to meet. For example, a mechanical engineer referred to how differences in scale influenced the choice of tools used:

“They build thousands of their printers, where we just build hundreds of ours. So it makes a big difference for the approach you can make when you design parts. If you make thousands of them, it is a lot cheaper when you spend money on tooling. So there are a lot of things there that we have to do differently.” (Mechanical engineer, Canada)

A software engineer from Canada noted, regarding the different kinds of tools needed to do work:

“In terms of toolsets, at least some people in the Netherlands are real fans of their tooling. It is a really big, very expensive content- and development-management scheme that has a very steep learning curve, and can result in efficiencies if used well by practitioners who have enough time to understand what is going on. And a lot of the work of the Dutch requires this tool as the framework. Kind of when you need Notepad and only Notepad because it is simple and needs to be simple, while using Word is much more sophisticated but time consuming. Here, people like having the ability of getting their hands down right at the lowest level, and take control. But it means you have to know exactly what you are doing, because you are taking on that responsibility. With the Dutch system, it means that your hands are off, like power steering in the car, or using features in Word to balance the look in the text. It takes a lot of time to learn something simple like Microsoft Word.” (Software engineer, Canada)

The choice for design tooling in both locations had been made years before, and since that time, the tools had been used separately for designing and to store and retrieve knowledge about technical designs. For Graphic’s R&D organization, having different technologies integrated within a virtual-design tool such as a CAD system had been the way to retrieve and use established technologies in new projects. In both the Canadian and the Dutch sites, the 3D-CAD system had become embedded within daily practices and formal documentation, and over the years, routines were built around the tool. Consider the following remark from one of the engineers in the Canadian unit:
“And then the way that we work is quite different too. Like GraphicNL is originally such an old organization. They’ve kind of grown… like they established a lot of processes and ways of working that are way more formalized than what happens here. Which makes it difficult as well to get either side to change, really… and meet in the middle.” (Manager electrical engineering, Canada)

This quote reveals one of the reasons why both units found it too complex to change to another design format. The format each had originally used for so many years had become so crucial to its daily practice that changing from it would not just mean a change in routines in the Mesa project, but a change in how its entire R&D program was structured and how it functioned in general.

The 3D-CAD tool did not get off the ground as a shared boundary object because both locations used their own highly embedded and incompatible version of this boundary object already. Although it is difficult to compare a design tool with a wiki environment, the wiki environment was less embedded within previous work practices of both units, but was shaped as part of the new joint field and therefore easier to adopt in the joint Mesa project. Both units were able to work with the wiki without having to give up their own routines or invest too much extra effort in the tool.

3.4.4. Building New Joint Fields

As the findings suggest, the extent to which a boundary object has been developed and used in previous settings within different groups that are expected to collaborate, has a significant influence on how a boundary object can be shaped and used in a new joint field. New joint fields, which are created to pursue joint interests, in which actors can overcome the embeddedness of practices from other fields (Orlikowski, 2002), and in which they can jointly shape and develop a new shared practice context, do appear to be somewhat neutral fields. From this point of view it is assumed that the development of a shared practice context involves the creation of boundary objects that have the same kind of impartial character, or are at least the subject of negotiations, before being used in the new joint field. In this way, the new joint field maintains its impartial
character, which is essential for joint-knowledge work to evolve (e.g., Frost & Zhou, 2005; Nonaka & Konno, 1998). If the new joint field is created and if it matures over time, obviously new shared routines are formed through practice in this field. However, as can be seen in the case of the CAD tool, it is not always possible to introduce an impartial boundary object within a new joint field. If boundary objects in new joint fields have a history in other fields, where actors are using the same boundary object, then these actors will see the boundary object as familiar and embedded within their routines. If some of the actors in the new joint field have previously used another boundary object that is similar to the new, shared boundary object, but not similar enough to be compatible with their local boundary object or with existing routines, this can cause difficulties for both groups. Part of the newly formed group can transfer its existing routines within the new field, by using their local boundary object, while another part of the group will not be in the same position. In the Mesa project, the new joint field became equipped with partly biased boundary objects that neither of the joining groups could adopt from each other.

3.5. Discussion

The purpose of this study was to understand how knowledge integration takes place in dispersed R&D settings in general, and more specifically, why some boundary objects within project Mesa were highly successful in bridging boundaries between dispersed R&D teams, while other boundary objects important for collaboration were not successfully established within the new project setting. Besides differences in terms of the flexibility of the structural design of the boundary objects themselves, findings show that when they partly overlap with established and embedded boundary objects within separate fields, there is an impact on how they can be established in new joint fields. When boundary objects are already embedded in local practices, it becomes difficult to embed them in a new shared practice context. My analysis helps us understand how routines that shape boundary objects in one setting can hamper the adoption of boundary objects with similar functions in other settings. The embeddedness of boundary objects at different Graphic sites had different impacts on the establishment of new joint fields. Furthermore, the boundary objects in my example show different levels of interpretive flexibility,
and this also plays a large role in how easily boundary objects can be copied from one field and adopted in others.

The contribution is twofold. I have shown that the historical use of boundary objects with similar functions in local settings can play a key role in the adoption of boundary objects in new joint fields. Furthermore, I show how the history and local embeddedness of boundary objects can lead dispersed R&D workers perceive these objects in a biased way. An awareness of this bias allows us to better understand how these boundary objects can affect the creation of a shared practice context in which joint R&D projects can take place. The key role that organizational routines play in this process has been touched upon.

3.5.1. Theoretical implications

This case is not the only example of local boundary objects that do not succeed as impartial boundary objects in joint fields. Other studies have shown conflict in the use of boundary objects in collaboration (e.g., Henderson, 1991; Leonardi, 2009; Levina & Vaast, 2005; Nicolini et al., 2011), frequently because they could not fit properly with the existing context of people and work practices. In view of new joint fields this is an important finding, since the bias that some boundary objects can give rise to can play a large part in these joint fields have been organized in a neutral way in the first place and, if so, to what extent. I found that the fact that boundary objects work properly in one context does not automatically imply that they can be transferred to, or function well in, other, apparently similar contexts. Although the word “object” could give us the impression that boundary objects are loosely coupled and easily transferable, I show that the historical and local embeddedness of these objects shapes how they can be transferred to a new joint field (see also Bechky, 2003; Carlile, 2002). This has implications for the literature on managing dispersed R&D. If objects have taken some sort of historical path and have become embedded within existing fields, they can be somewhat biased for actors in new joint fields. Levina and Vaast (2005) discussed the difference between designated boundary objects and boundary objects in use, in which objects in the former category can be seen as “intended” but not necessarily fulfilling their role as boundary objects, while the latter shows enough characteristics to facilitate new joint fields at all times. Especially in dispersed settings, boundary objects will be designated by management, instead of emerging more naturally through routines.
as boundary objects in use. Considering my conclusion that routines from different groups have a strong influence on how boundary objects are formed in existing fields on the one hand, and adopted by new fields on the other, an interesting avenue for further research could involve exploring in more detail how routines and boundary objects interact.

Another implication can be found in the way new joint fields are observed in a more general sense. As I noted above, the literature on new joint fields in R&D gives the impression that these fields are new neutral settings in which different groups of actors come together to build a shared practice. My findings show that these fields are not necessarily neutral impartial but that they can largely consist, rather, of elements that different groups bring along from their own existing fields. I have regarded boundary objects as important building blocks or elements of new joint fields, and my findings contribute to the literature on new joint fields by addressing the interpretation of these fields as being new. These tools are established to create a shared context between different groups, but it would be interesting for the conceptual development of new joint fields to further examine how biased boundary objects fit within this context.

3.5.2. Practical implications
Interestingly, if objects do not fulfill the role of bridging boundaries, for example if they cannot support new joint fields, it becomes questionable whether these objects are actually boundary objects. The distinction between designated and in-use boundary objects (Levina & Vaast, 2005) could imply that my example of the 3D-CAD system shows that it is similar to a designated boundary object that did not get off the ground. However, the boundary objects that were used in the Mesa project, such as the wiki, meetings, or documents, could not substitute for the CAD system either. The historical path and resulting embeddedness of boundary objects are an important point to consider for managers who have to decide on designated boundary objects. A practical implication from this study for managers would therefore be to assess how a biased boundary object that is crucial for collaboration might in one respect seem to facilitate a dispersed project, but in another turn out to hinder collaboration efforts. As my findings reveal, biased boundary objects can turn out to hold back the ability to realize dispersed R&D collaboration.
3.5.3. Limitations and further research

Taking into account Star and Griesemers’ (1989) criteria of boundary objects’ being flexible enough to be interpreted and used by different actors, our example of the 3D-CAD system as a boundary object could be questionable. Although the system was intended as a boundary object, it did not turn out to meet the requirement of interpretive flexibility. Following other empirical work on how boundary objects did not always succeed in their boundary-spanning function, such as some designated boundary objects described by Levina and Vaast (2005), I decided to identify the system as a boundary object for two reasons. First, because the 3D-CAD system was seen as a (potential) boundary object (they tried to “make it work” as a boundary object), it was similar in some respects to designated boundary objects. Second, as for the actors involved, there was no alternative system to use for the shared tasks of integrating technologies and designing a new product. The possibility of adopting a boundary object that would be flexible enough for both groups was not available at the time. The decision to study intended boundary objects that have been successful in existing contexts but that do not become boundary objects in their new context, allows us to take a closer look at why boundary objects meet with different levels of acceptance in different fields, just as I have done by looking at the embeddedness and the routines shaping these objects.

Another limitation can be found in generalizability. Although the dataset that this study is based on contains a single case study from which two examples of boundary objects are highlighted, I have attempted to identify some important implications for the conceptual development of boundary objects and new joint fields. To increase the generalizability of these implications, a further step would be to investigate this in more detail in a large-scale study on how various boundary objects, both with and without a history of being locally embedded, have different impacts on establishing new joint fields.
KNOWLEDGE POLLINATION: FACILITATING ORGANIZATIONAL LEARNING IN GEOGRAPHICALLY DISPERSED SETTINGS

This chapter addresses the question of how MNCs can overcome the complications for organizational learning that result from the locally embedded character of knowledge. Based on a case study on the role of internal engineering consultants (ECs) in an MNC in the energy sector, I identify the process of knowledge pollination, which describes how an established yet flexible network of knowledge workers can help in overcoming the embeddedness of local knowledge by pollinating knowledge between dispersed settings. Like bees collecting and transferring pollen from flower to flower, these internal ECs temporarily embed themselves in a local practice, transferring the knowledge they already carry and collecting new knowledge to take to the next local practice. The findings show how this organizational learning process constitutes a combination of learning in practice (sharing practices within specific projects and at specific locations), transactive memory (using the personal network in terms of knowing who knows what and being able to make sense of this knowledge through interaction), and organized learning (institutionalized tools and structures to facilitate the sharing of knowledge). Learning in practice is the core process of creating and applying knowledge, transactive memory facilitates this process across different local and practical contexts, and organized learning facilitates the development and extension of transactive-memory systems between individuals.
4.1. Introduction

How can an MNC re-use relevant, locally created knowledge in other parts of the organization? Because knowledge is often embedded in the local context of subunits or projects, it is difficult to transfer this knowledge to other locations. Studies on MNCs show that the creation of local knowledge is valuable for organizations when it comes to meeting local needs, realizing economies of scope and scale, and exploiting local resources (Gupta & Govindarajan, 2000; Ghoshal and Bartlett, 1988; Nohria and Ghoshal, 1997; Zander and Kogut, 1995). The notion that MNCs derive competitive advantage by exploiting relevant, locally created knowledge has been supported in numerous studies on global integration (e.g., Ghoshal & Bartlett, 1988; Nohria & Ghoshal, 1997; Zander & Kogut, 1995), but drawbacks associated with transferring locally embedded knowledge, such as poor transparency or transferability, have also been exposed (e.g., Cummings & Teng, 2003; Gupta & Govindarajan, 2000; Sole & Edmondson, 2002). This creates a challenge for an MNC that is seeking to stimulate the creation of locally relevant knowledge and, at the same time, to somehow disembed that knowledge from its local context and re-embed it in the larger organization, in order to make it more universally applicable within the organization (Hong and Nguyen, 2009). In recent years, researchers have investigated organizational knowledge flows in the context of MNCs from different angles, such as the transferability of subsidiary knowledge (Foss & Pedersen, 2002; Minbaeva, Pedersen, Björkman, Fey & Park, 2003), determinants of knowledge patterns (Gupta & Govindarajan, 2000; Kogut & Zander, 1993), multiple embeddedness (Almeida & Phene, 2004; Figueiredo, 2011) and organizational learning (Lam, 2003; Schultz, 2001). With this study, I empirically investigate how a particular group of internal ECs within an MNC copes with the embeddedness of local knowledge and organizational learning in practice.

Empirical studies on organizational learning in geographically dispersed settings have addressed key problems of the embeddedness of local knowledge that limit the ability of organizations to effectively tap into their broad organizational knowledge base. For instance, Cramton (2001) addresses the “mutual knowledge problem” of geographically dispersed collaboration by identifying key communication obstacles that hinder learning in dispersed teams. Figueiredo (2011) reports that, to overcome local embeddedness in dispersed collaborative settings, multiple embeddedness is necessary—i.e., embedding people and their knowledge in both
local and corporate contexts. Hsiao *et al* (2006) discuss how the fact that practices (and their related knowledge) are embedded in different work contexts complicates managing knowledge at an organizational level. The way the embeddedness of knowledge in different, geographically dispersed contexts complicates organizational learning is discussed by Hong and Nguyen (2006), Lahiri (2010) and Sole and Edmondson (2002). These studies build on the idea that overcoming the barriers that the embeddedness of local knowledge creates for organizational learning requires connections between local settings through knowledge-intensive interactions. The study presented in this paper connects to this idea by focusing on how internal ECs—a specific group of experts that supports projects and locations worldwide with specific solutions to, and advice on, complex problems that subsidiaries are faced with—contribute to organizational learning by overcoming the embeddedness of local knowledge. The general research question in line with the complete dissertation is: How can the embeddedness of knowledge be coped with in integrating dispersed R&D knowledge? At the end of the theoretical background of this chapter (paragraph 4.2.1), this research question will be defined more specifically for the case study at hand.

I use a grounded theory approach to empirically investigate the role of internal experts in dispersed organizational settings. Using semi-structured interviews as primary data, I identify a process, referred to as *knowledge pollination*, which describes how an established yet flexible network of knowledge workers can help in overcoming the embeddedness of local knowledge by temporarily embedding themselves in a local practice, *disembedding* the knowledge from that local practice, and *re-embedding* it when they participate in another local practice.

This paper is organized as follows: the following sections review the literature on the embeddedness of local knowledge and the nature of knowledge-intensive work within the context of MNCs. Then, the organizational context of an MNC that is specialized in energy technology, and my research design, are presented. The empirical findings show that, although ECs work in geographically dispersed settings, they favor both the informal process of *learning in practice* and their *transactive memory* (over organized learning) as most valuable for tapping into the organization’s knowledge base. I explore the ways ECs learn and apply their expertise in practice in local settings, introduce the concept of *knowledge pollination*, and describe how this can be seen as a way to cope with the embeddedness of local knowledge. The chapter concludes by
drawing implications from the empirical findings, in order in turn to shed light on how MNCs can facilitate organizational learning in a way that takes into account the situated and integral nature of complex knowledge work.

4.2. Theoretical background

4.2.1. The embeddedness of knowledge

Setting the scene for this study requires an explanation both of the problematic nature of the embeddedness of knowledge and of the complexity of knowledge-intensive work in dispersed organizational settings. Argote and Ingram (2000) discuss how knowledge is embedded in people, tools, routines, best practices and related sub-networks. In geographically dispersed organizational settings, knowledge is embedded within the local context it is created in, influenced, for example, by different technologies, practices, social contexts, culture, and timing. (e.g., Brown & Duguid, 2001). This embeddedness is important for the development of critical knowledge (Grant, 1996), since it is developed within a specific context, to serve a specific goal. However, organizations often aim to integrate this embedded knowledge into the wider organization in order to use it as a critical resource in other settings. This is where the embeddedness of knowledge becomes problematic: embedded knowledge is difficult to grasp since it is intrinsically connected to its original context. The idea behind the embeddedness of knowledge is that knowledge cannot be moved and used elsewhere in an organization without a “transfer of clusters of individuals with established patterns of working together” (Teece, 2000: p. 36). Knowledge developed in one local setting becomes situated and embedded in its context and practices, and cannot readily be applied in another local setting. Correspondingly, the more complex and embedded the knowledge, the more difficult to re-use it elsewhere.

Reviewing studies on knowledge-intensive work, i.e., complex work that brings forth new knowledge, such as R&D work, reveals at least two specific characteristics that describe the nature of this kind of work (Dougherty, 2001), henceforth knowledge work, and that explain the complexity of the embeddedness of knowledge. First, knowledge work has a situated nature, which means that it is inextricably bound up with social and practical contexts (Brown & Duguid, 2002; Lave & Wenger, 1991). The work itself is realized within a context in which many different activities of the knowledge process are interrelated, and can therefore be understood
only by actors understanding this particular context. Taking the example of R&D work, it is not clear-cut work for which the course of action is set from beginning to end; rather, it emerges from a process of learning by doing, in which actors understand the nature of the setting and move towards a solution with specific features of the context in mind (Carroll, 1998; Dougherty & Takacs, 2004; Schön, 1983; Tyre & Von Hippel, 1997). This means that knowledge work, and the knowledge involved in that work, are likely to remain embedded in people and practices (Brady & Davies, 2004; Carlile, 2002; Orlikowski, 2002; Sole & Edmondson, 2002; Swan, Scarbrough, & Newell, 2010). Second, knowledge work has an *integral nature*, which means that different knowledge domains are integrated on several levels so as to realize new knowledge from different areas in the organization (e.g., research, manufacturing, marketing, business) (Clark & Fujimoto, 1991; Kogut & Zander, 1992). Studies looking into this integral nature discuss, for instance, the process of heedful interrelating, which refers to the process in which individual knowledge workers contribute to integral work by understanding the system of joint action and then interrelating their contributions within this system in order to jointly solve problems or develop new products (Dougherty & Takacs, 2004). More specifically, while knowledge workers tend to be specialized in parts of the knowledge-development process, it is the awareness of, overlap and adjustment to the representation of joint action that are essential to the integration of these different knowledge domains (Clark & Fujimoto, 1991; Leonard-Barton, 1995).

These two characteristics raise tensions in the guidance of knowledge work in terms of the embeddedness of the knowledge involved. In the context of MNCs’ geographically dispersed settings, these tensions become even more manifest. Knowledge workers have a tendency to specialize in a certain knowledge domain in a situated context (e.g., Brusoni, Prencipe & Pavitt, 2001; Collinson & Wang, 2012). At the same time, the integral nature of knowledge work requires the combination of different knowledge domains, *i.e.*, the process of heedful interrelating. So while knowledge work has an integral nature, separate knowledge domains concurrently tend to disintegrate and specialize, which makes combining these knowledge domains more complicated (Brusoni *et al*, 2001; Erkelens, Van den Hooff, Huysman & Vlaar, 2010; Grant, 1996). The geographical dispersion of knowledge work increases specialization and decreases combinative abilities (Ensign, 1999; Lahiri, 2010; Postrel, 2002) by increasing the
salience of the local context in which knowledge is created and applied. Even within the boundaries of a dispersed project setting, the lack of social interaction and direct collaboration decreases the ability to share context-specific and tacit knowledge (Birkinshaw, 2002; Hinds & Mortensen, 2005; Levina & Vaast, 2005).

In sum, the embeddedness of knowledge in local contexts complicates organizational learning, especially in geographically dispersed settings, because of: (1) the situated nature of knowledge practices, and the people and knowledge involved in those practices, which means that these practices are likely to remain embedded in specific local contexts, and (2) the physical boundaries of space and time which are caused by geographical dispersion and which increase the local embeddedness of these practices—in turn because of decreased social interaction and direct collaboration between organizational units and their members. Given that knowledge is situated and embedded in people and practices, an important way to connect different practices is to exchange the people involved in those practices: the knowledge workers. In this process, knowledge workers themselves become embedded in different contexts, practices and locations. This raises the question of how these knowledge workers acquire, create and apply knowledge within changing local settings, and transfer knowledge between these settings. I explore this idea within the context of an MNC specialized in energy technologies, in which internal ECs work in varying local contexts (locations, projects) within the organization. These consultants are renowned experts in a certain area, are well known within the organization, and have been requested to contribute their specific expertise when it is required at particular locations or in particular projects. My specific central research question is: How do ECs help overcome the embeddedness of local knowledge in practice?

4.3. Methods

4.3.1. Research design

Because I am interested in providing insights into how a specific group of experts deals with locally embedded knowledge in their work, I have chosen to do a qualitative study. The use of in-depth interviews allows me to explore in rich detail how ECs learn and exploit their expertise in different settings, as well as telling me what role these consultants have in the process of
organizational learning in dispersed organizational settings. Furthermore, taking this qualitative approach is useful for understanding and articulating processes such as organizational learning (Pratt, 2009), something that cannot be realized by predefined quantitative research only. Since, to my knowledge, not much research has been done to investigate the role of ECs in overcoming local embeddedness, and certainly not in a real practice setting (to investigate what they do instead of how it theoretically should be done), a more emergent approach towards theory-building is adequate (Eisenhardt & Graebner, 2007; Shah & Corley, 2006). This study therefore follows an inductive approach in which theory is identified and developed through interactions between empirical data, existing theory, and emergent theory (Eisenhardt & Graebner, 2007; Gioia, Corley & Hamilton, 2012; Langley & Abdallah, 2011).

4.3.2. Data collection
The empirical data on which this study is based were collected over 11 months in 2011, in a large MNC specialized in energy technology, which is listed in the top 5 of the Fortune Global 500 list (2012). In what follows I refer to this company as “EnerTech.” When I was collecting these data, the company employed approximately 90,000 people. It is vertically integrated within the energy industry, from upstream oil-and-gas exploration activities to downstream product development and sales, and has locations in more than 80 countries. By design, most of its projects are geographically dispersed, and projects always include a variety of engineers from several sublocations and headquarters. As part of a long-term program on retaining critical knowledge within the organization, a department specialized in knowledge management within the company provided me with access to ECs (and their managers) who had been taking part in geographically dispersed internal and external projects.

The ECs’ support was requested by several departments and locations within the company, in tasks ranging from performing lab research, to writing technical advisory reports for specific facilities, to full assignments within engineering teams in projects at several locations. They usually had certain expertise or experience with technologies which is not held by local departments or project groups. For example, one of my interviewees, an explosion expert, was frequently asked to investigate and advise on explosion hazards at local plants and oil rigs. He is one of the few experts on this matter within the company, and he develops his expertise further
with every assignment for which he is internally hired. Most of the assignments entail an EC’s becoming part of a project team, either at R&D or at local facilities. All of the interviewees in the sample, including in this case, had accumulated between 10 and 35 years’ experience within the company, which allowed the interviews to be elaborate and cover my research topic in depth.

I relied primarily on 23 semi-structured individual interviews with technical-, chemical- and mechanical-lead engineers, full senior engineers, and senior engineers with managerial occupations, specialized in upstream and downstream energy activities. The interviewees were selected at random after I had identified the large pool of experienced ECs. It turned out that nearly all ECs within EnerTech had more than 10 years’ engineering experience within the company, most of them within the same job, and this provided me with a representative sample for the organization. Before confirming interview dates, I first tried to check the interviewees work history by searching the Internet and by asking the knowledge-management department for details on the interviewees’ roles. It turned out that 22 of the 23 interviewees had worked in different locations in dispersed collaborative settings within EnerTech. One interviewee had worked on different locations but did not have an engineering background. However, since this person was specialized in best-practice knowledge-retention programs within projects, I believed that the insights gathered could be useful for my dataset as well. Details of the interviewees are presented in Table 4.1.

I conducted 20 interviews face-to-face in several locations in the United States and the Netherlands, and 3 interviews by phone, using an interview protocol that is presented in Appendix B. The interviews lasted 52 minutes on average, with a total of 20 hours and 45 minutes of recorded material. All interviews were fully transcribed. I also relied on several meetings with knowledge managers regarding knowledge-retention issues in the company, and on observations during knowledge-retention sessions between ECs. This secondary data offered me an adequate context in which the interviews could be conducted and further analyzed.

Table 4.1. Details of interviewees at EnerTech

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Location (place, country)</th>
<th>Function/employed</th>
<th>Duration interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>R., The Netherlands</td>
<td>Technology specialist advisor</td>
<td>00:55:51</td>
</tr>
<tr>
<td>X2</td>
<td>R., The Netherlands</td>
<td>Explosion specialist</td>
<td>01:03:38</td>
</tr>
</tbody>
</table>
The interviews were semi-structured. The first part of each interview concerned more-structured questions in order to retrieve data on the ECs themselves, for example the number of years of employment, their expertise, and their employment history at the organization. The rest of the interview was generally less tightly structured but did cover fixed discussion topics and questions about my research interest: knowledge retention, knowledge retrieval, learning, problem-solving, and collaboration in dispersed settings. I attempted to use vocabulary that was familiar to and practical for the interviewees, and tried to avoid theoretical constructs such as “absorptive capacity” or “the embeddedness of knowledge.” Table 2 below represents codes I traced in the data, entailing problems identified and challenges arising from the embeddedness of local knowledge, which I used as input to further define my interview questions. These questions included:
- How do you approach a new assignment at different locations? Can you give an example? Can you describe how you make sense out of a new local context? How do you work with people at one or another location? How do you apply what you learn in one location to another assignment at another location?

- What challenges do you face when doing assignments at different locations? What sorts of knowledge are involved in such assignments? How do you gather the knowledge you need for your assignments?

- Can you describe how you interact with your assignment locations? What people do you interact with? Can you give examples of what you learn during your assignments? Can you give examples of how you apply your expertise at specific locations?

These questions were followed up with more-specific questions on topics introduced by the employee. Approaching the last couple of interviews, I experienced theoretical saturation in the part I became most interested in (Glaser and Strauss, 1967), namely, how these interviewees deal with locally embedded knowledge across different contexts.

### Table 4.2 Codes on the embeddedness of knowledge

<table>
<thead>
<tr>
<th>Codes from quotes in the interviews (1st order coding, open and axial)</th>
<th>Categories (2nd order coding)</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the context of the problem</td>
<td>Situated nature</td>
<td>The embeddedness of knowledge</td>
</tr>
<tr>
<td>Not retrievable through reports only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need to be within practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-standard solutions</td>
<td>Integral nature</td>
<td></td>
</tr>
<tr>
<td>Process of heedful interrelation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience with similar problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance of network development through practice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.3.3. Data analysis

The interviews, once transcribed, were coded in Atlas.ti on several levels. I developed schemes from open/initial/first-order coding where different parts of text in the interviews were coded with “subject codes.” These ranged from “years of employment” and “problems related to IT infrastructure” to “face-to-face importance for knowledge-sharing” (e.g., Charmaz, 2006; Gioia et al, 2012; Van Maanen, 1979). I also coded specific activities such as formal and informal
knowledge-sharing sessions and how interviewees used the organization’s formal databases and libraries to retrieve knowledge. This resulted in data on what kind of instruments or methods were used for knowledge-sharing purposes, and how useful these instruments were in daily practice. Next, I coded deductively and with somewhat more focus by means of codes derived from the interview protocol. This approach allowed me to remain close to the broad research approach I had started with, and to analyze the data through different lenses than can be used with open coding (Charmaz, 2006; Eisenhardt, 1989). These rounds resulted in a list of first-order codes which mainly represent the activities of ECs and how they learn, and apply their knowledge, in the organization. For the generation of second-order codes I drew on first-order codes and through a number of iterations I were able to categorize these activities into more-general codes. The second-order codes are generated with a priori theory in the background, as this allows more-analytic coding and further understanding of the phenomenon I was analyzing (Charmaz, 2006). Based on analysis and constant comparison of these first rounds (Glaser and Strauss, 1967), concepts emerged from the data (Table 4.3, third column), and iteration with theory and critical discussion amongst the researchers resulted in axial (higher-order) coding schemes for different emerging theoretical frameworks such as transactive memory, learning in practice and embeddedness of knowledge, and the importance of informal knowledge processes. The data set was recoded deductively after the concepts were developed, in order to thoroughly check consistency in coding and to elaborate on the concepts generated (Eisenhardt, 1989). For example, after having generated the concept of transactive memory from iterations between theory and the second-order codes, I recoded the data set on this concept and included more coding on how ECs develop relationships with others by embedding themselves within the context of projects or locations. This resulted in the data structure that appears in Table 4.3. Appendix E provides a simplified but more inclusive overview of the coding structures. Figure 4.1 provides a rough overview of formal and less formal interactions with the company, the research team, reviews, and theory during the analysis of the data.
<table>
<thead>
<tr>
<th>Codes from quotes in the interviews (1st order coding, open and axial)</th>
<th>Categories (2nd order coding)</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeking expertise from other ECs</td>
<td>Seeking/asking advice</td>
<td>Transactive Memory</td>
</tr>
<tr>
<td>Consulting other ECs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asking focal points for reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building relationships with other ECs</td>
<td>Building relationships</td>
<td></td>
</tr>
<tr>
<td>Building relationships within projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building relationships within locations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion with colleagues on technology</td>
<td>Negotiation</td>
<td>Learning in practice</td>
</tr>
<tr>
<td>Coffeepot method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interrelating between experience and context</td>
<td>Heedful interrelating</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creating a project overview</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
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<td>Job handover</td>
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<td>Practices worth replicating</td>
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<td>Workshops on lessons learned</td>
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<td>Introduction courses at sites</td>
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<td>Writing down general project guidelines</td>
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<td>Understanding context of problem</td>
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<td>Not retrievable through reports only</td>
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<td>Process of heedful interrelation</td>
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<td>Importance of network development through practice</td>
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Figure 4.1 Interactions during data analysis
In the next section, this analysis is used to describe how ECs learn and exploit knowledge within their practice settings within EnerTech. I use representative quotes in the text to portray my findings (e.g., Pratt, 2008). Table 4.3 provides additional quotes as evidence for my observations.

4.4. The embeddedness of knowledge at EnerTech

In order to provide sufficient context for the findings discussed below, it is important to understand what formal technical roles ECs at EnerTech have. The following quote, in which a distillation expert explains his work, is illustrative:

“My work can be explained in two parts. One part is work in projects. Large projects within EnerTech, if they require equipment we are responsible for, then we make the designs ourselves. Those are sometimes quite general designs, further elaborated on in collaboration with the site and contractors at location. That is about 40 percent of what I am doing. The other 60 percent entails technical maintenance. If a site has a problem because, for example, heat will not transfer correctly, I will fly in and take a look at how I can solve their specific problem. I work with furnace equipment, which uses a lot of fuel, and which can and will explode sometimes. If something like this is the case, I investigate what happened, try to learn from this, and try to make sure it does not happen at other sites.” (X23, distillation expert)

As the quote illustrates, the broad role of ECs at EnerTech is to provide advice and solutions to specific existing and future technical problems that locations may encounter, and to provide expertise to developing projects. Generally, ECs are brought into locations or projects when sufficient knowledge is lacking locally, or when an expert is needed, for example for technical support in legal contracts.

The following paragraphs report my main findings. To better understand the phenomenon of the embeddedness of local knowledge, I will first explain how ECs in my sample make use of the organization’s pre-structured knowledge-retrieval systems, before elaborating on how they overcome the embeddedness of local knowledge in practice.
Table 4.4. Supporting quotes for first- and second-order codes

<table>
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<th>Categories (2nd order coding)</th>
<th>Codes from quotes in the interviews (1st order coding)</th>
<th>Supporting quotes</th>
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</table>
| **Heedful interrelating**     | Interrelating between experience and context decision-making  
                                  Creating project overviews  
                                  Problem-solving          | “OK. You are some kind of broker between projects. You bring experience from one project to another project.” (X3)  
                                  “Eventually it is a complicated process. The (P) project has about 50 functional technologies which all have to align. I have lessons, but also problems with individual technologies in the specific situation of (P). I have to overcome this by aligning in the bigger picture.” (X22) |
| **Negotiation**               | Discussion with colleagues on technology  
                                  Coffeepot method          | “If you compare two cars, you cannot say one is good and one is absolutely bad. One might be more expensive, it might require less maintenance, and the other is less expensive but needs more check-ups. What is good and what is not is not all that black and white. All solutions have their benefits and drawbacks. That is something you have to learn to deal with.” (X19)  
                                  “We (ECs) talk to each other a lot. It is often difficult to have coffee chats since we are worldwide. I am in the middle of time zones, so I have half a day with Bangalore and half a day with the H (place in US). I also help these colleagues with other things than technical stuff.” (X2) |
| **Asking advice**            | Seeking expertise from other experts  
                                  Consulting other experts  
                                  Asking focal points for reference | “I conducted a study on a similar C (chemical process) plant in P (place in Europe) a couple of years ago. And then my colleague in Bangalore notes my expertise on this matter, and contacts me knowing that it should be relatively easy for me to solve.” (X2)  
                                  “Calling people. A typical answer to your question is just two phone calls away.” (X17)  
                                  “I can write a report, I can send it to colleagues, I know what to do with reports of colleagues, I know where it is filed, but I can never find the relevant knowledge I need. While it might be that the report is very well written! The only way to get this information is to experience the problem situation yourself and then to ask colleagues.” |
Building relationships

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<th>Building relationships</th>
<th>Building relationships within projects</th>
<th>Building relationships within locations</th>
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<td>(X2) “They (experts) have to make sure they manage to build a strong relationship with people on the locations, in such a way that they can help locations further. And, through this relationship, they (the experts) can also identify problems at hand. [...] In this way they create new assignments, which help EnerTech as an organization. This is one of the benefits of experts, that is clear.” (X4)</td>
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<td>(X2) “Sharing knowledge means talking to people, knowing what they are doing, what they are thinking. That is something you need to do within this organization.”</td>
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<td>(X7) “I must say, in all honesty, that it is of much more value, you get much more feedback, and you are able to get work done through personal contacts. Not through the formal process, but just from colleagues’ during their work. They notice something is not working properly, they come back to the group and then try to discuss another approach. Very informal.”</td>
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4.4.1. Organized learning

Most of the interviews with ECs began with the respondents explaining the different “formal” knowledge-sharing systems, such as documentation systems, libraries, and report-filing systems. It soon became clear that the downsides of knowledge retrieval through these systems manifested themselves in three ways: first, when searching for information in the company’s databases, ECs experience knowledge silos for different technical areas and locations, as knowledge is often embedded within restricted organizational systems. Different sub-systems, and confidentiality within library documents, make finding the right information “time-consuming,” “problematic,” or “impossible.” Second, if the information is found, ECs find it to be either too general or too specific to be readily applicable to their work. This is because reports are either project-specific or technology-specific and lack sufficient detail for present purposes. Knowledge in these reports is developed within a specific context and therefore becomes embedded within this context. Third, since technology develops and changes quite fast within EnerTech and its industry, ECs
explain that they often do not trust that the information in reports and databases is adequate and up to date.

ECs do not seem to rely entirely on formal documentation as the primary resource for their work. Nevertheless, they do explain the importance of the documentation systems, namely to identify related technological reports, to understand why certain technical choices were made in the past, and to search for the people who wrote specific documents. As will become clear in the following sections, searching for formal documentation is merely used as a way to find experts on a certain (technological) issue.

Besides documentation for knowledge retrieval, ECs explain the importance of organized sessions and workshops in which knowledge such as experiences and new technologies is shared in groups that meet either in person, or via conference calls or video conferencing. From my data, I identified numerous initiatives for organized learning, such as weekly progress meetings within teams, workshops on “lessons learned,” “ask the expert,” and “practices worth replicating” sessions. ECs note that these arranged learning sessions are crucial to understanding what and how the organization is doing worldwide, to learning where expertise resides—whether in locations or with other ECs—and to getting updates on new technology solutions. A similar downside of formal documentation was revealed for these organized learning initiatives. The knowledge provided is not often useful for solving the specific problems at hand. As an EC explains:

“I have many different examples of retaining my critical knowledge, through all kinds of arranged face-to-face sessions, workshops, reports, guidelines. But whenever I need critical knowledge in projects, I cannot rely on these sources. Too often I have to conclude that either the knowledge is outdated for use in recent projects or too general or detailed to fit in what I am doing. How I handle this? I go to the expert or to someone who knows where I can find the expert on this matter. And this person I can talk to, I discuss, and he explains this and that in exactly the way I can use it.” (X6, senior technologist)
This quote illustrates the need for ECs to access knowledge sources that are more specifically tailored to the problem situation at hand. Overall, the interviewees explain that the particular assignments they have require specific knowledge on, for example, local technologies, practices and contexts, to which more general organizational knowledge is not sufficiently applicable.

The knowledge required by ECs is clearly not found through formally organized knowledge-sharing, although ECs mention this as often being the start of their search for the right insights. Since my interest lay in understanding how ECs do manage to acquire the right organizational knowledge for their assignments, the interviews subsequently tended to focus on discussing how ECs, in the practice of their work, tapped into the organization’s knowledge base.

4.4.2. Learning in practice
As the last quote in the previous section partly reveals, ECs explained that most of what they learned and applied in the field was acquired in the practice of the work itself, and by getting in contact and discussing technology with other experts. Most of the ECs in my sample explained that they had developed their own way of finding specific knowledge, expertise and solutions for their assignments. Soon it became clear that ECs develop their own informal network of other ECs and experts on location, from whom they retrieve the necessary specific knowledge. A combination of their own insights, the specific context, and specific knowledge retrieved from their network enables ECs to deliver optimal solutions for their projects. The following two quotes help explain how ECs use their networks for finding specifics on their assignments:

“I always check whether this was done before at another location. If someone gets allocated to a project, and doesn’t dig deep enough for recent developments, this person will probably try to reinvent the wheel. Then I talk to focal points or approach colleagues and ask whether they have experience. I do not count on proper filing, and if I do, I cannot find what I am looking for.” (X8, mechanical materials specialist)

“It did happen naturally [building network]. I hire very smart people at EnerTech and the first thing they’ll do is go and find out who has done it before. Finding
and storing in my systems can be very difficult. But, finding a person, sometimes it is much easier. That’s how they do it. It happens. I see it. I do it. Everybody does it.” (X1, technology specialist advisor)

My analysis revealed some informal practices that characterize learning in practice for ECs, divided into two informal practice routines (Table 4.3). The first, *negotiation*, consists of discussion with colleagues and the so-called coffeepot method. Discussion with colleagues is explained as negotiating technologies in response to the practice at hand, in order to create common sense, to “field-test” one’s new idea or solution with colleagues, and to learn from others’ insights. The idea of a coffeepot method (as interviewees call it) is quite similar; the difference is that conversations between ECs and/or other specialists are not planned, but begin because people happen to meet coincidentally at the coffee machine (or printer, water cooler, etc.) and start a conversation about their practices. Negotiating knowledge with other ECs and colleagues gives ECs the opportunity to discuss otherwise specialized and embedded knowledge in a more general way, in order to disembed and explain it. By the same token, ECs learn new insights from others by discussing and exploring others’ work contexts. The following quote from a mechanical-materials specialist represents the negotiation category:

“…Yes, but often it is on an informal basis (interacting with colleagues). It happens when you see somebody at the coffee machine, or you approach a person if you have a specific problem and you know he has experience with it. Whenever you need it… and not only when you need it, because often at the coffee corner or during walks to the ferry on my way home I often discuss technical problems. Or often during lunch. In this way, I have a lot of technical information exchange.” (X8, mechanical materials specialist)

The second informal practice routine that I identified relates to *heedful interrelating*, consisting of four sub-routines that all describe how ECs interact in practice: interrelating between experience and context, decision-making, creating project overviews, and problem-solving (Table 4.3). Interrelations between experience and context represent the core of heedful interrelating, in which the other three categories mainly reside. It explains how ECs make sense of the situation at hand by using their experience in other contexts, and how they consequently develop an adequate
(technical) solution to an assignment. More conceptually, the ECs become embedded in the local practice, participating in the application of locally embedded knowledge, while at the same time introducing their existing knowledge into this local practice. For example, an EC who was part of the geophysics team, and who specialized in the management of data on wells, explained that he had been requested to support a large new well project in US. The project team had asked for him because he had experience with setting up similar well projects in Canada. He had to examine the situation at hand and monitor progress during the start-up phase. During this project, the EC took actions at two important moments, actions that eventually prevented the project from making mistakes that had been made in previous projects. He applied and re-embedded his knowledge from other sites into this particular project. As the EC explained:

“Because of my experience in some Canadian projects, I was called in for an assignment last year. Data management is considered a discipline now, just as geology, for example, so I am considered an expert when it comes to well data management. During monitoring, I discovered some inconsistencies in the data, which needed further analysis. Because I recognized the situation from another project, I understood that this could become a serious situation. Luckily I could notify the project leader and advise the team accordingly.” (X15, geophysicist)

The EC explained how he developed experience in practice and how, through what he had learned from past experiences, he could identify a similar critical situation in another context. This example represents the importance of learning in practice, and applying what is learned in new settings. Here it is interesting to note that the way ECs work truly involves a process of heedful interrelating and not a structured procedure in which the actions taken by the EC are clear from beginning to end. Rather, they constitute a process in which every action taken is preceded by an EC’s assessment of the situation at hand, by being part of the local context and using his experience, while at the same time being aware of the larger organizational context (the “joint action”) through his experience in different contexts. The following quote explains how an EC creates an overview of the situation, and combines what he knows from practice with up-to-date information at hand in order to make adequate decisions on how a situation should be dealt with:

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“Let’s say there is a chemical hazard of concern that the HSC technicians or I find during the HRA process. I need to do some monitoring to find out whether there are exposures that occur. I would then either work with the technicians to collect that information, or the hygienist would go out to the location and collect that information. I would assemble or compile the data and report back with recommendations […] I need this interaction to make the right choice.” (X12, senior industrial hygienist)

Although EnerTech is an MNC with projects that are usually geographically dispersed with people who are not working together physically, ECs value their work in practice and the informal person-to-person network as being the most important for their learning process, and, consequently, for their performance during their assignments. I therefore took a closer look at how ECs learn from their networks.

4.4.3. Transactive memory

Besides embedding themselves within local contexts and relying on experience, ECs explained that the best way to retrieve specific knowledge within the organization is through contacting colleagues with experience on a specific matter. Direct contact with other experts (e.g., experts on technology, projects, or local contexts) obviates the need for ECs to deal with knowledge that is either too general, too specific, or outdated, as explained earlier. An EC can discuss his/her interest with a colleague who has more experience on a specific subject, and through this interaction they create a shared understanding of the situation at hand. Combining “knowing where knowledge can be found” (transactive retrieval) and “being able to make sense of this knowledge through interaction” (encoding) resembles the concept of transactive memory (Wegner, 1987). Within the category of transactive memory I was able to identify two sub-categories of activities through which ECs learn and retrieve knowledge, namely seeking advice and building relationships.

Seeking advice involves directly approaching the person in the organization who is most experienced in a specific knowledge domain. ECs explain that seeking advice is accomplished by
asking focal points in the organization to redirect them, by consulting other experts the EC is already familiar with (he/she knows the expert), or sometimes by including another expert within the assignment. Again, although the organization and its ECs are geographically dispersed, ECs continually explained to me that this dispersion did not seriously interfere with their way of getting to the most suitable knowledge available at that moment. As an EC (a chemical engineer and focal point) indicated: “After many years of working for EnerTech I know now who knows what, and colleagues know my expertise too. We find each other, that is the way we work.” Another EC (a lead reservoir engineer) told me: “I pick up the phone and at max three calls later I am talking to the right person. I don’t do searches in my database, I search my network. It is all informal.”

The “informal” network, as ECs call it, is the network of professional contacts ECs develop themselves throughout the years. They explained that the context they were working in afford them a setting in which it was natural to seek advice from and provide it to most colleagues. Building relationships within this context is therefore essential, both with other “experts” as well as with people in projects and at locations (who are sometimes the same actors). ECs explained how the three types of relationships differed in terms of the kinds of knowledge sources they were interested in. Building relationships with their fellow experts was mainly vital to finding knowledge within a specific technology domain, such as “cat-cracking” (X6), “industrial hygiene” (X12), or “soil and ground-water expertise” (X10). Other experts have built experience by participating in various practices in these areas, learning from and contributing to the locally embedded knowledge in different local contexts. Building relationships with people in projects is vital for accessing the multidisciplinary or project-related knowledge that is embedded in the specific project context. Moreover, ECs value the development of the shared social and practice context in which they work, both in order to facilitate collaboration in projects and to present themselves as knowledgeable consultants for future assignments. Building relationships with people at locations was seen as important to retrieve local knowledge and to create an understanding of the local context around an assignment. These people may be technical experts too, but are more permanently stationed at one location and strongly embedded within the local context. The following quotes characterize the importance of the ECs’ transactive memory:
“Well, in ‘EnerTech world’ a lot depends on your networks. In this team in R (place in the Netherlands), because you work in all the regions, you need to have a good network in the regions as well. That’s the way that EnerTech works, and I think the way any normal organization works as well, but EnerTech probably more than others.” (X3, technology specialist advisor)

“They [ECs] have to make sure they manage to build a strong relationship with people on the locations, in such a way that they can help locations further. And, through this relationship, they (the ECs) can also identify problems at hand. […] In this way they create new assignments, which help EnerTech as an organization. This is one of the objectives of ECs, that is clear.” (X4, chemical engineer and manager)

ECs primarily use their transactive memory to tap into knowledge that is either embedded in people, practices, or locations. By doing so, they are able to adequately reach relevant, locally embedded knowledge, which in other ways is too difficult to retrieve or understand. Yet, although organized learning (documentation, organized workshops) does not provide ECs with the knowledge they are searching for at that moment, it does support the development of ECs’ transactive memory. Formal documentation might not provide adequate detail, but it does provide an overview of whom to approach for more-precise knowledge—an overview that is much larger in scope than the ECs’ existing personal network. Likewise, organized sessions and workshops develop transactive memory in that ECs gain an overview of where knowledge can be found for future assignments.

4.4.4. Knowledge pollination

Taking the three processes identified—organized learning, learning in practice, and developing transactive memory from an individual learning level towards a group- and organizational-learning level—the ECs at EnerTech play a crucial role in overcoming the embeddedness of knowledge by pollinating knowledge between dispersed locations. ECs do this by working in different locations in the organization, with different people, using different practices, as
identified in the previous chapters. They become embedded within a setting they are assigned to, participating in the practice and the application of locally embedded knowledge in this context, while at the same time sharing a part of their critical knowledge with the people, practices, technologies and networks within that setting. They apply what is learned to the next practice, and at the same time participate in the creation of new knowledge within that practice. More conceptually, ECs are able to embed themselves in a practice setting, to absorb and disembed knowledge from that setting, and to re-embed this knowledge in the form of applying their expertise in different practice settings. My analysis of the way ECs learn in practice and through their networks offers insights into how ECs consistently apply and enrich their expertise in different practice settings. I call this knowledge pollination, which I see as a multiple-way process for sharing, creating and applying knowledge in practice. Like bees collecting and diffusing pollen from flower to flower, ECs collect and simultaneously diffuse their expertise from context to context, and in this way pollinate knowledge through the organization. An EC explained this as follows:

“Especially when they are people who have experience—for example, if they are working in Nigeria, in the Middle East, in Russia. Working in the countries is an experience in itself. Yes, you might have similarities in terms of, for example, Nigeria demands local content and Russia does too. But is it the same approach, what is the difference, which one is more efficient that you can influence even when you go and work in that country and say, “You know what? In Nigeria they do this this way, perhaps there is an opportunity to improve your content in Russia.” Those types of things are good to have in mind.” (X16, standards and assurance expert)

The process of knowledge pollination is a process that is inextricably linked to the ECs’ practices—it is an outcome of the way ECs work, traveling from practice to practice, learning and teaching, creating and applying knowledge within different contexts. It is not a deliberate cross-pollination process, as neither the organization nor the EC deliberately organized the phenomenon, nor are ECs permanently transferred to pollinate knowledge.
Thus, ECs facilitate organizational learning at EnerTech by doing justice to the situated nature of learning (and thus to the locally embedded nature of knowledge), while still being able to extend this process across specific local contexts. ECs do not cope with the challenge of locally embedded knowledge by trying to extract it from the practice in which it is created and applied, but by participating in the practice. Through this participation, they make sense of the specific knowledge that is embedded in this context. In addition to this learning in practice, the interaction with other ECs (facilitated by transactive memory) provides them with insights into the specific knowledge these other ECs have. This knowledge then becomes part of the knowledge they subsequently apply in the next practice in which they become involved. Because projects at EnerTech are by nature geographically dispersed and ECs are allocated to varying locations, this next practice will typically take place in a completely different local context. A chemical lead engineer working at different plants in Europe explained how ECs generally work:

“Because you habitually talk with colleagues about solving problems, you end up hearing, “Hey, I could solve it in a better way if I would do this and that in this and that way.” Or it could be that you build on experiences you developed elsewhere. That is an advantage of having dispersed and changing teams. My people do not only do this for the one location in P (city), but also for M (city) and two locations in Germany. And ECs, they seek advice to also work in a bunch of other locations and for third parties. So I have developed a much broader view of how you can solve a particular problem. The interaction between people on the location who really know the local situation and my people, who often have more experience and a broader view on what possible solutions are at hand. Bringing those together.” (X4, chemical lead engineer)

4.5. Discussion

The purpose of this study was to understand how ECs develop their expertise while working in geographically dispersed locations and how these insights can meet the challenge of overcoming the embeddedness of knowledge in dispersed organizational settings. I conducted a study at an MNC specialized in energy technologies. The qualitative approach allowed me to obtain in-depth
insights into the way ECs work and develop expertise over time. From my analysis I concluded that ECs mostly create, develop and transfer knowledge in the course of practice and through their transactive memory. Although EnerTech is a geographically dispersed organization with locally embedded critical knowledge, which is almost impossible to share through organized learning (documentation and organized sessions and workshops), I identified how ECs are able to learn and retain critical knowledge by pollinating previously embedded knowledge throughout the organization. I name this collection of activities knowledge pollination, and describe how learning in practice and transactive memory are essential for executing this emergent process.

4.5.1. Theoretical implications

My findings contribute to theory in several ways. First, I introduce the concept of knowledge pollination as a process of how experts, in my case ECs, are able to tap into locally embedded knowledge, develop and transfer this knowledge throughout the global organization, and in this way enhance organizational learning. More specifically, I discuss why and how ECs play a crucial role in overcoming embeddedness by pollinating knowledge in the organization. Namely, because ECs understand where critical knowledge resides, and through their experience, they are able to understand critical knowledge within its context, and disembed as well as re-embed knowledge. The sub-categories I identified and by which they pollinate knowledge (heedful interrelating, negotiation, asking advice, and building relationships) provide insights into how ECs play a crucial role in overcoming the embeddedness of local knowledge.

The concept of knowledge pollination seems closely related to the concept of knowledge-brokering. Indeed, the engineering consultants in my study also “translate, coordinate, and align” (Hargadon, 2002) between different perspectives on EnerTech’s globally dispersed activities, and also “link practices by facilitating transactions between them” (Wenger, 1998, p.109), creating new knowledge by combining knowledge domains (Burt, 1992; Dimaggio, 1992). However, the concepts differ in at least three important ways. First, the role of knowledge brokering as described in organization science is mainly a role that is allocated to certain individuals. For knowledge brokers it is an imposed task to bridge boundaries between different thought worlds through activities such as organizing workshops, databases, or reports (Sverrisson, 2001; Kramer & Wells, 2005). Knowledge pollinators do not have the explicit task of helping different worlds
understand each other. Rather, emerging from practice, it is a process whereby relevant local knowledge is articulated in other fields, without the objective of making this knowledge explicit for different parties. Second, in literature on knowledge brokering, it is argued that brokers are “in between worlds” (Hargadon, 2002; Lomas, 2007; Meyer, 2010) or at the “periphery of practice.” Here, knowledge pollinators are not explicitly bridging worlds but are rather able to embed themselves within the center of the practice context, so as to create sufficient understanding of embedded knowledge for their own assignments. Third, brokered knowledge is translated knowledge (Osborne, 2004) that is often made more robust, accountable, and usable for different groups (Meyer, 2010). If the objective of knowledge pollination were to make knowledge accessible in the way described in theories of knowledge brokering, the focus would instead be on organized learning, while the focus of knowledge pollination is on learning in practice and on transactive memory. Here, knowledge is not “transposed” to a higher level of abstraction, but is re-embedded in different contexts through application. My findings show that the kind of knowledge involved, because of its integral and situated nature, is intrinsically bound to practice and that it is unusable when it has been extracted from its context.

Secondly, my findings contribute to the literature on managing the embeddedness of knowledge in dispersed organizational settings. By looking at how ECs tap into embedded knowledge and how they develop individual experience in practice, I provide a micro-level perspective, and by relating this to the macro-level perspective of how the role of ECs can facilitate overcoming the embeddedness of local knowledge within dispersed settings, I aim to contribute to the literature on this embeddedness of knowledge. For example, Figueiredo (2011) discusses multiple embeddedness as a dynamic capability, arguing that knowledge-intensive links between subsidiaries and headquarters lead to better and more innovative performance on the part of subsidiaries. My findings add to this by providing an understanding of how ECs can create and use these knowledge-intensive links and how relevant, embedded knowledge is then shared within the expert network. Mudambi and Swift (2011) discuss how organizations benefit from recognizing that critical knowledge is embedded and that it resides within communities of practice, technology, and networks. My study also recognizes the notion of embeddedness in people, technologies and practice, and elaborates on this finding by discussing how key actors can pollinate this critical knowledge across embedded contexts, by disembedding and re-
embedding it. ECs contribute to multiple embeddedness by being embedded in multiple contexts, and are therefore able to bridge these contexts, and pollinate knowledge through their practices.

Third, my findings contribute to the literature on intra-organizational networks by explaining that knowledge integration between locations can benefit from a flexible and shifting network that spans several locations and projects (Alcacer & Zhao, 2011; Cross & Cummings, 2004; Lahiri, 2010; Nahapiet & Ghoshal, 1998; Tsai & Ghoshal, 1998). My study elaborates on these intra-organizational networks and takes a closer look at how organizations can realize organizational learning within these networks. Besides showing that an established network serves the wider organization’s knowledge-integration purposes by providing direct and indirect links to up-to-date and applied critical knowledge, my analysis also shows that this knowledge integration occurs in the actual practice setting, and is often too complex to capture in a more formal way. I add to the literature on intra-organizational networks by introducing the concept of knowledge pollination, and explain how knowledge can flow through an organization’s expert network. The four informal practice routines I identified—heedful interrelating, negotiation, asking advice, and building relationships—link to some extent to individual capabilities on how to establish intra-organizational networks.

4.5.1. Practical implications
The integration of knowledge-intensive work in dispersed organizational settings contributes to organizations’ competitive advantage (Benner & Tushman, 2003; Katila & Ahuja, 2002; March, 1991; Zollo & Winter, 2002) but little is known about how individuals in organizations accomplish this. I specify three practical contributions that shed light on the way management can deal with knowledge integration in dispersed settings. The first explains that transactive memory (i.e., knowing who knows what) in dispersed organizational settings can help to overcome the embeddedness of local knowledge, not so much by extracting knowledge from practice, but by learning whom to consult for critical knowledge and collaboration opportunities. Although knowledge is not forcefully extracted for the purpose of creating organizational knowledge, through established transactive memory it is accessible for actors in the organization who can understand and use it: the ECs and other experts in the organization.
Second, my view on the work of ECs in dispersed organizational settings brings forth the concept of **knowledge pollination**. The four practices I identified can help managers understand how knowledge-intensive links between dispersed locations work, and how they can facilitate these practices accordingly. I explain how ECs develop critical insights in different local contexts and, through practice, pollinate this critical knowledge in several other projects and local contexts.

Third, the management of dispersed organizational collaborations often encounters difficulties in the way people in dispersed locations can share knowledge and collaborate because of differences in language, time, culture, and because of the lack of a common social and praxial context (Birkinshaw, 2002; Cummings & Teng, 2003; Lahiri, 2010). In order to overcome such difficulties, organizations develop more-standardized procedures, strictly allocate responsibility, and try to codify knowledge in order to transfer it (Cummings & Teng, 2003; Lam, 2000). While this tendency to increasingly standardize and codify knowledge could improve coordination between dispersed collaborations, my findings show that critical knowledge-sharing benefits from practices that involve direct interactions between people. The awareness of this finding could help management focus on interventions involving more-personalized activities.

In conclusion, an important insight for management is that the embeddedness of knowledge can be overcome through a combination of learning in practice, transactive memory, and organized learning. Where many organizations tend to emphasize organized learning (i.e., managing codification, implementing various structures, and sessions for knowledge-sharing), it is important to realize that such activities are primarily of value by virtue of their role in facilitating the creation, maintenance and extension of transactive memory. This transactive memory, in turn, plays an important role in facilitating the process of learning in practice at various locations and in various projects, and it is this process which is at the core of knowledge pollination.
CHAPTER 5

SPECIALIZATION AND INTEGRATION IN DISPERSED R&D: CHALLENGES, TENSIONS, AND MANAGEMENT APPROACHES

This chapter reports on a qualitative study conducted at the R&D departments in a number of MNCs about their process of managing knowledge in geographically dispersed settings. The tension between specializing units into centers of excellence, and trying to find integration opportunities in such dispersed settings, creates challenges for management. This study approaches these challenges from both managerial and practice-based perspectives to managing R&D. Using data from interviews, I illustrate the tension between specialization and integration, and identify management processes for coping with such tension. Moreover, I present a model for dispersed R&D management that reveals the interrelatedness between several challenges, as well as the learning curve for performance over time.
5.1. Introduction

In recent years, MNCs have increasingly adopted a global approach to R&D, dispersing these activities across various geographically distributed units (Frost & Zhou, 2005). Geographically dispersed R&D units can be thought of as centers of excellence based around particular functional and local specializations, which form a rationalized structure for innovation in a globalized environment (Frost et al., 2002; Moore & Birkinshaw, 1998). These distributed centers of excellence create in-depth, specialized knowledge in specific domains and markets (Von Zedtwitz & Gassmann, 2002). While an organization can benefit from such specific knowledge, the increased specialization that results from the dispersion of R&D also presents some important challenges in terms of knowledge integration between different R&D units and the wider organization (e.g., Birkinshaw, 2002; Cummings & Teng, 2003; Lahiri, 2010).

The argument is built on the central assumption that effectively managing dispersed R&D knowledge requires both specialization (in centers of excellence, creating in-depth knowledge about specific technologies and markets) and integration (of this specialized knowledge across the different units and the organization as a whole) (Postrel, 2002; Singh, 2008). A second central assumption is that there is a tension between specialization and integration: specialization is by its very nature an emergent process that takes place when specialists collaborate on a shared practice (Brown & Duguid, 2001; Carlile, 2002), whereas integration requires deliberate management efforts in which knowledge is to some degree extracted from specific practices and transposed to a more general level (Brusoni, Prencipe & Pavitt, 2001; Clark and Fujimoto, 1991; Kuemmerle, 1997). Such deliberate efforts are often found to fit poorly with the emergent processes of knowledge creation and sharing, thus creating a tension (Agterberg, Van den Hooff, Huysman & Soekijad, 2010; Brown & Duguid, 2000). Third, I assume that this tension is more manifest in distributed than in centralized settings, as the lack of a shared social and practice context (because there is less face-to-face interaction and direct collaboration between units) increases the tendency to specialize in distributed units, as it complicates the integration of knowledge from across these units (Boh, Ren, Kiesler & Bussjaeger, 2007). Several specific challenges result from the tension between specialization and integration. The aim of this chapter is to identify these challenges for the management of R&D in distributed settings, as well as the processes through which these challenges are dealt with in achieving a balance between the two.
The general research question guiding this study is therefore: How can the specialization and integration of knowledge be managed in dispersed R&D settings?

This study follows an inductive exploratory approach, based on semi-structured, in-depth interviews with 62 managers and key informants directly involved with global R&D in four MNCs. My analysis is primarily focused on the actual practices of R&D people: engineers, consultants and managers, and the knowledge issues they encounter in these practices. Through a qualitative analysis, I identify challenges in terms of creating an organizational structure, a social context, shared practices, and organizational knowledge, and I reveal different processes through which these challenges are related one to another, as well as specialization and integration objectives.

Through this analysis, this chapter makes two main contributions to the literature. First, the majority of past and current research approaches the tension between specialization and integration from a purely managerial perspective (e.g., Almeida & Phene, 2012; Carnabuci and Operti, 2013; Lahiri and Narayanan, 2013; Tippman, Mangematin & Scott, 2013). My focus on the practices involved in this tension emphasizes the importance of going beyond such a perspective. An analysis of the micro-processes involved in distributed R&D provides a richer insight into the challenges and “coping” processes with regard to balancing specialization and integration than an analysis that primarily focuses on strategic and managerial goals and interests. Second, I contribute to the literature by emphasizing the processual character of managing distributed R&D, stressing the interrelatedness between the different challenges involved in managing specialization and integration across space and time. Thus, I emphasize the dynamic character of managing knowledge specialization and integration in dispersed R&D, showing how different R&D processes are interrelated and how they reinforce each other, at the same time elucidating which specific management activities help to balance both specialization and integration.

The chapter is organized as follows. First, I discuss the specific nature of dispersed R&D work, and address recent studies on specialization and integration in more detail. This overview presents a priori literature used to code and analyze my qualitative data, as explained in the methods section. From the analysis of first- and second-order concepts, a model is derived, which
will be explained in the findings section. I elaborate on the interrelatedness of processes in the model by presenting a short vignette at the end of the findings. In the discussion, I elaborate on my findings and discuss the implications and contributions of my research.

5.2. Theoretical background
The literature on managing R&D provides an insight into (1) the specific nature of R&D work and how this creates a tension between specialization and integration, and (2) how the geographical dispersion of R&D activities exacerbates this tension. Dougherty (2001) identifies three specific characteristics of R&D work: that it is integral, situated and emergent. This combination of characteristics can be helpful in explaining why both specialization and integration are crucial in managing R&D, and why a tension between them is likely to arise. I discuss each of these characteristics in detail, and explain why a dispersed R&D setting makes the combination of these characteristics especially complicated.

First, the integral nature of R&D refers to the interrelatedness of activities that are part of research and development, and emphasizes the importance of integrating knowledge across various specializations. In R&D, different knowledge domains are combined to form the knowledge assets necessary for problem-solving and innovation (Clark and Fujimoto, 1991; Kogut and Zander, 1992). Although such integration can be difficult to achieve in co-located settings (because of the situated nature of R&D knowledge, as explained below), a distributed set-up of R&D activities complicates matters even further. In a co-located setting, an important element of the integration of knowledge across different domains is the process of heedful interrelating. This is the process in which individual knowledge workers contribute to integral work by understanding the system of joint action and then interrelating their contributions within this system to solve problems or develop new products (Dougherty and Takacs, 2004). A combination of awareness, overlap, and adjustment to the representation of joint action is essential for this process to take place, and this strongly depends on the opportunity to meet face to face and to collaborate (Clark & Fujimoto, 1991; Leonard-Barton, 1995). Such a shared context (both in terms of social interaction and shared practice) is considerably more difficult to achieve in a dispersed setting, where the distance between locations (geographical, organizational
and cultural) severely reduces the interrelatedness of activities and the opportunities to collaborate. Consequently, the integration of R&D knowledge across domains is further complicated when R&D work takes place in geographically dispersed settings.

Second, R&D work is situated in a social and practical context (Brown and Duguid, 2002; Lave and Wenger, 1991; Tyre and von Hippel, 1997), which means that the work consists of a process of “learning by doing,” in the physical context of use, application, or operation. The creation, sharing and application of knowledge are situated within the context of a shared practice around which direct collaboration takes place (Brown & Duguid, 2001). This practice-based collaboration between experts leads to specialization (Carlile, 2002), as experts dig deeper and deeper into the details of their shared practice. The context-specific and often tacit nature of this increasingly specialized knowledge makes it impossible to share it with other contexts without a sufficient degree of social interaction (Birkinshaw, 2002; Hinds & Mortensen, 2005; Orlikowski, 2002). Dispersing R&D work across local contexts is likely to increase specialization, since it reduces the opportunity for heedful interrelating, as explained above, thus raising barriers to the sharing of practices and prohibiting rich social interaction. In order for R&D workers in a particular unit to fully understand the meaning and purpose of knowledge that was created in another unit, they have to understand the context in which the knowledge was created. In a dispersed R&D setting, knowledge is created and shared within different local contexts, and this makes creating a shared understanding of others’ knowledge even more complicated than in co-located settings.

Third, R&D work is characterized by the emergent nature of working standards. This means that innovative work requires flexibility in adjusting the configuration of the process during the practice itself, and does not combine very well with top-down efforts to control the process (Dougherty, 2001; Tatikonda & Rosenthal, 2000; Van de Ven & Poole, 1987). This points to a tension that is central to managing processes of knowledge and innovation between the emergent nature of these processes on the one hand, and deliberate management efforts to establish integration amongst these processes on the other (Agterberg et al, 2010). Where specialization (because of the emergent nature of the process) requires a hands-off, laissez-faire approach, which is often described in terms of stewardship (Wenger, 1998), care (Von Krogh,
1998), cultivation (Ward, 2000), nurturance (Alvesson, Kärreman & Swan, 2002), or fine-tuning (Alvesson & Kärreman, 2001), the integration of knowledge across these specializations requires a more active, top-down involvement on the part of management (Grant, 1996; Spender, 1996). Thus we see the “balancing act” between process and practice that Brown & Duguid (2000) refer to, and which is also reflected in the literature on innovation. It points to a balance between exploration and exploitation (Raisch & Birkinshaw, 2008). This tension, I contend, is even more manifest when R&D work is geographically dispersed. As explained above, the integral nature of R&D work requires a process of heedful interrelating in which different knowledge domains are combined towards the achievement of a joint goal, and this process requires a shared context that is considerably more difficult to achieve in geographically dispersed settings. Often, this lack of a shared context is partly compensated for by more formal coordination and communication mechanisms (Dougherty, 2004; Erkelens and Van den Hooff, 2012; Hinds and Mortensen, 2005), and this in turn increases the distance between emergent knowledge-specialization processes on the one hand, and deliberate integration efforts on the other.

In sum, the integral and situated nature of R&D work means that it requires both integration and specialization. The emergent nature of R&D work leads to a tension between integration and specialization, and a tension between the management approaches (deliberate versus emergent) required to achieve them. The dispersion of R&D activities, in turn, increases the tendency to specialize as well as the need for more deliberate ways of integrating knowledge, intensifying this challenge in comparison to co-located R&D settings. As a response to the lack of an (informal) shared practice context, management often tends to prescribe and impose more process standards. While more agreement on processes is being reached by shared standards and allocated responsibilities, the flexibility needed to make adjustments to these standards and responsibilities decreases. This means in turn that the emergent and situated nature of the work that R&D requires is constrained by an increase in structure and policy measures. Instead of creating knowledge, this can lead to inertia in the organization’s R&D processes (e.g., O’Reilly & Tushman, 2008). Table 5.1 helps understand how a tension between specialization and integration becomes more evident in dispersed settings—a tension that needs to be empirically explored in more detail in order to be fully understood. In the following section, I discuss the methods I used in further exploring these issues.
Table 5.1. Specialization and integration in dispersed R&D

<table>
<thead>
<tr>
<th>Characteristics of R&amp;D work</th>
<th>Specialization/integration approaches</th>
<th>Problematizing dispersed R&amp;D activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrelatedness of activities, combining different knowledge domains (specializations)</td>
<td>Need for integration, requires relationships and rich interaction</td>
<td>Otherwise naturally organized processes and activities require different forms of organization for collaboration</td>
</tr>
<tr>
<td>Context bound, situated nature and a social process</td>
<td>Natural tendency for specialization</td>
<td>Lack of shared context to situate and participate in collaborative R&amp;D work</td>
</tr>
<tr>
<td>Emergent nature of standards, experimentation and improvisation</td>
<td>Tension between emergent approach, which leads to specialization, and deliberate approach, which leads to integration</td>
<td>Increasing tension because of the need for more deliberate approaches that lead to a more-emergent process</td>
</tr>
</tbody>
</table>

5.3. Methods

5.3.1. Research design and setting

My research aims to offer an in-depth understanding of how specialization and integration relate and are managed in practice. This prompted me to select a qualitative research design. The use of in-depth interviews allows exploring, from a practice perspective, how individuals experience working in geographically dispersed settings. It also enables me to investigate in detail how engineers and managers experience tensions between the emergent approach to R&D work and the more deliberate management interventions for knowledge-integration purposes. Investigating such relationships requires room for exploration and flexibility in the research design, which is difficult to realize with deductive (quantitative) designs (Pratt, 2009). Since research into specialization and integration in real practice settings, according to our knowledge, lacks detailed insights into how the two concepts relate in practice and what processes are essential for managing the two, and I therefore follow a more emergent approach to theory-building. This is realized by inductively developing theory from interactions between empirical data, existing theory, and emergent theory (Eisenhardt and Graebner, 2007; Gioia, Corley and Hamilton, 2012; Langley and Abdallah, 2011; Shah and Corley, 2006)
The empirical data for the study were collected between February 2009 and June 2013 in four multinational R&D organizations: one in the chemical industry, one in energy-technology development, and two high-tech developers. The organizations were selected based on the global presence of their R&D locations, some of which were offshore and interviewees were identified during introductory meetings and follow-up interviews. Interviewees were selected based on their experience in international R&D projects, and they were identified as key persons in managing or executing dispersed projects. I chose this selection method so as to ensure enough detail and at the same time to get enough of an overview to identify important processes relating to specialization and integration efforts.

5.3.2. Data collection and analysis
I conducted 62 interviews with managers at different levels and engineers from different disciplines. The general interview protocol contained questions regarding a respondent’s position, his or her history with the company, a typical working day, relationships between units, and learning moments in working with geographically distributed R&D units. Once a general overview of the situation of the interviewees had been obtained, the protocol became more focused with questions regarding, for example, specialization and integration, and collaboration and communication between units. An overview of the interviews and organizations can be found in Table 5.2.

<table>
<thead>
<tr>
<th>Company profile</th>
<th>Interviews (65)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company A</strong></td>
<td>Managers (10)</td>
</tr>
<tr>
<td>&gt; 20,000 employees</td>
<td>Engineers (23)</td>
</tr>
<tr>
<td>R&amp;D Units in, e.g., the Netherlands*, Canada, Romania</td>
<td></td>
</tr>
<tr>
<td><strong>Company B</strong></td>
<td>Managers (3)</td>
</tr>
<tr>
<td>&gt;100,000 employees</td>
<td>Engineers (2)</td>
</tr>
<tr>
<td>R&amp;D units in, e.g., the Netherlands*, China, USA, UK</td>
<td></td>
</tr>
<tr>
<td><strong>Company C</strong></td>
<td>Managers (2)</td>
</tr>
<tr>
<td>&gt; 10,000 employees</td>
<td>Engineers (2)</td>
</tr>
<tr>
<td>R&amp;D units in, e.g., the Netherlands*, India, USA, Poland, Australia</td>
<td></td>
</tr>
<tr>
<td><strong>Company D</strong></td>
<td>Managers (5)</td>
</tr>
<tr>
<td>&gt; 100,000 employees</td>
<td>Engineers (18)</td>
</tr>
<tr>
<td>R&amp;D units in, e.g., the Netherlands*, China, USA, India, Argentina</td>
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</tbody>
</table>
The interviews, which took 75 minutes on average, were fully transcribed and coded in Atlas.ti. Interpretations of the facts, made by the researcher and stories told by the interviewee were discussed during the interviews, thus fostering mutual understanding, which in turn enhanced the quality of further levels of interpretation (Kvale, 1989). Transcription was undertaken soon after each interview, and each interview was separately reiterated during the transcription process, thus offering an understanding of the interviewees’ thoughts as well as a grasp of the organization’s characteristics. During this process, concepts and constructs were identified and discussed by the researchers involved in this study. Following the “Gioia method” (Gioia et al, 2012), first-order concepts (empirical observations) and second-order concepts (theoretical observations) were identified, and were recoded after a first round to ensure consistency in coding. Possible constructs and concepts regarding factors influencing knowledge specialization and integration were proposed, but were separated from subsequent interviews in order to prevent premature or false conclusions.

During the coding process, and specifically during the development of second-order themes, I noted the distinct way in which interviewees described how knowledge was managed in the organization, namely through a focus on either the knowledge itself or on the people involved in knowledge processes. Because interviewees kept the two foci separate in their descriptions, I chose to keep this view as a distinction between “connections” (people) and “content” (knowledge).

Table 5.3 shows my data structure for each of the identified concepts, themes, categories, and processes. Appendix F provides a simplified but more inclusive overview of the coding structures. From this data structure and from further analysis through the identification of relations (processes) between the aggregate categories, I arrived at a research model (Figure 5.2.) that will serve as a structure for describing the findings in the next section of this chapter. Figure 5.1 provides a rough overview of (formal) interactions with the company, the research team, reviews, and theory during the analysis of the data.
<table>
<thead>
<tr>
<th>Codes from quotes in the interviews (1&lt;sup&gt;st&lt;/sup&gt; order coding, open and axial)</th>
<th>Categories (2&lt;sup&gt;nd&lt;/sup&gt; order coding)</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchy (managers) Reporting Knowledge boundaries in projects Bringing the right people together Task allocation in projects</td>
<td>Formal agreement on the interface</td>
<td>Organizational structure</td>
</tr>
<tr>
<td>Relation between R&amp;D, marketing &amp; sales Dispersed teams</td>
<td>Network</td>
<td></td>
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<tr>
<td>Communication system Collaboration structure Communication between locations Communication within unit</td>
<td>Facilitating a context for collaboration</td>
<td></td>
</tr>
<tr>
<td>Formal/informal connections Change ways of working Breaking barriers Overcoming confidentiality issues</td>
<td>Overcoming problems associated with different ways of working</td>
<td>Establishing connections</td>
</tr>
<tr>
<td>Willingness to collaborate problems/frustrations between settings Building relationships between settings Awareness of differences between cultures/units</td>
<td>Motivation</td>
<td>Social context</td>
</tr>
<tr>
<td>Awareness of differences in knowledge base Awareness of different ways of working Language Awareness of me/them perception</td>
<td>Trust</td>
<td></td>
</tr>
<tr>
<td>Cross-referencing (combining knowledge to learn from each other, using each other’s solutions)</td>
<td>Identity</td>
<td></td>
</tr>
<tr>
<td>Knowledge-sharing mechanisms Procedural knowledge Kind of knowledge involved Coaching/mentoring Face-to-face meetings important</td>
<td>Creating knowledge in practice</td>
<td>Situated learning</td>
</tr>
<tr>
<td>Experience Local knowledge Knowledge residing in projects Knowledge in techniques</td>
<td>Collaboration among engineers</td>
<td></td>
</tr>
<tr>
<td>Knowledge difficult to retain Knowledge developed through practice Asking advice</td>
<td>Embeddedness of knowledge</td>
<td>Shared practice context</td>
</tr>
<tr>
<td></td>
<td>Emergent knowledge</td>
<td></td>
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<tr>
<td>Integration</td>
<td>Extracting knowledge from practice</td>
<td>Articulating content</td>
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<tr>
<td>Make experience explicit Reporting</td>
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<tr>
<td>Formal knowledge-sharing</td>
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<tr>
<td>Formal/informal learning</td>
<td></td>
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<tr>
<td>Retrieving knowledge</td>
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<tr>
<td>Learning from projects</td>
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<tr>
<td>Internal knowledge</td>
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<tr>
<td>External knowledge</td>
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<tr>
<td>Use in other parts of the organization</td>
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<tr>
<td>Finding knowledge</td>
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<tr>
<td>Protecting knowledge</td>
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<tr>
<td>Silos</td>
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<tr>
<td>Building up R&amp;D unit</td>
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<tr>
<td>Project/technology ownership</td>
<td></td>
<td></td>
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<tr>
<td>Efficiency/innovation issues</td>
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<tr>
<td>Integration opportunities</td>
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<tr>
<td>Organizational goal setting</td>
<td></td>
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<tr>
<td>Understanding where knowledge resides</td>
<td></td>
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<tr>
<td>Meeting program managers</td>
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<tr>
<td>Organizational knowledge</td>
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<tr>
<td>Transparency</td>
<td></td>
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<tr>
<td>R&amp;D structure</td>
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<tr>
<td>Strategy development</td>
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<tr>
<td>Portfolio mapping</td>
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<tr>
<td>Roadmapping</td>
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</tbody>
</table>
Figure 5.1 Interactions during data analysis
5.4. Findings

Before going into the details of my empirical findings, I first outline the general structure according to which these findings are discussed. Taking a practice perspective, my data analysis primarily focused on two levels: the level of practice of the actual R&D work where specialization took place, and the managerial level of organizing for knowledge integration. As discussed in the theory section, specialization requires an emergent approach and is thus characterized as allowing specialization. Integration, on the other hand, requires a more deliberate approach and is thus said to achieve integration (see Figure 5.1).

**Figure 5.2. Achieving integration and allowing for specialization**

The data shows that goals and activities at both levels are described in terms of either content (the actual knowledge being created and exchanged) or connections (the ties between different units and/or individuals involved in R&D). Combining these two dimensions, I created the 2 x 2 model that is the core of Figure 5.1. Within the cells of this model, we find the challenges that management faces, in terms of the goals that needed to be met in order to manage dispersed R&D: creating an organizational structure (integration, connections), establishing a social context for collaboration (specialization, connections), creating a shared practice (specialization, content), and establishing organizational knowledge (integration, content). Connecting the challenges are the processes that need to be in place for management to meet them.
In order to allow for specialization to take place, I identified practices of situated learning that aim at facilitating collaboration through which practices are shared and practice-based learning takes place. This process is clearly a specialization process because this is where the situated and emergent nature of R&D work is manifest. The integrative nature of R&D work can be found in the process of roadmapping, aimed at integrating what is learned into new knowledge structures in the organization, i.e., organizational knowledge integration. Following this, the upper two cells of the model represent integration challenges, while the lower two represent specialization challenges. Because I am interested in how organizations balance specialization and integration efforts, I primarily focus on processes that “bridge” both levels. I identified two core processes: establishing connections, which is aimed at bringing people together so they can create social ties and work together, and articulating content, aimed at transposing situated, practice-based knowledge to an institutional level. Below, I explain my findings as depicted in Figure 5.1. I first describe situated learning and roadmapping, processes that either serve specialization or integration. Second, I discuss establishing connections and articulating content as processes that balance specialization and integration. Finally, I discuss the dynamic and interrelated nature of these processes, elaborating on the model as a whole in terms of a learning process.

5.4.1. Situated learning
The interviews illustrate that management recognizes the complex and embedded nature of R&D professionals’ activities. Managers are aware of the need for a laissez-faire approach, so that actual specialization can take place in a flexible and emergent environment. The process of situated learning is found to be embedded in practice, and management can only allow for specialization to happen. This process is depicted in Figure 5.1 as a process connecting the challenges of creating a social context and a shared practice. The arrow points both ways, because this is an iterative process between knowledge (content) and people (connections). More specifically, this is where specialization takes place, between people who share and combine their knowledge while working on a shared practice. Engineers explain that they can create new things
and develop new techniques, by combining their experience with what is at hand in a particular practice setting. For example, one project manager recalled:

“You know, eventually they come back to me with a new concept or design which has features which I can see coming from both platforms. The process they go through before they come to me is one that is incredibly complex. I can’t explain how they ‘generate’ new knowledge, neither can they.” (R&D Director, Company A)

An Indian manager comments on the sort of knowledge involved:

“I think the sort of things which are in the formal documents—whether in Bangalore or in the Netherlands—are easily accessible and understandable. But certain things, which are in the minds of the people, for that I do not know whether everything is transferred to the other person or whether it is transferred all. Because that is really unrealistic.” (Manager in India, company C)

Managers explain that the work engineers do is often too complex to understand and deliberately manage, and that such an approach can also be counterproductive. This process of working quite independently from management supervision, doing the actual research and design work, is what I call situated learning. It is a process in which knowledge and people (content and connections) are fully intertwined and embedded in practice. This is where specialization can take place in practice: through collaboration and with limited managerial supervision, engineers are able to assess and further analyze opportunities, deepen their understanding of the technologies at hand, and create more-specialized knowledge based on the context they are working in.

Managers show an awareness of the social process involved in R&D work. They recognize that managing situated learning is a really emergent process, and they understand that efforts are required to create a positive climate. These efforts are typical of a laissez-faire kind of approach, i.e., finding a balance between providing structure and providing enough room for creativity. Managers realize that their role is primarily to facilitate this process.
5.4.2. Roadmapping

Roadmapping describes the process of integrating what is learned into new processes, strategic directions, and structures in the organization. Given the integral nature of R&D work, this means that roadmapping requires the integration of organizational knowledge, derived from different parts in the organization. Organizational knowledge is used as input to determine what knowledge resides in the portfolio and how this can be deployed in new settings in the future, \textit{i.e.}, achieving \textit{organizational structure}. In this process, (corporate) management decides upon new courses of action. These decisions are made primarily by program managers, who obtain information on new opportunities from their own centers of excellence or project teams, and who subsequently keep each other informed. That leads in turn to new roadmaps for the R&D portfolio.

The organizations in the study show different “roadmapping” processes, starting from centralized decision-making in cooperation with the corporate organization on one end of the spectrum, towards independent roadmapping in more-autonomous units in local settings on the other end. This is reflected in the following quote:

“A couple of times a year we arrange the program-management-team meeting. Program managers and innovation managers of groups who join the program come together, catch up with each other, and discuss the program concerning content. An example: ‘Where are we going with our lighting division? What are important challenges?’ This way, we all get informed on what challenges are present. At the same time, I see these meetings as an opportunity to understand ‘This is important in the US,’ ‘That is important in Shanghai,’ and so forth.” (R&D Director, company B)

The two paragraphs above make clear that both specialization and integration efforts are important for R&D in an organization. Between challenges related to integration (upper cells in Figure 5.1) and challenges concerning specialization (bottom cells in Figure 5.1), I found the processes of \textit{establishing connections} and \textit{articulating content}. These will be discussed below.
5.4.3. Establishing connections

On the left side of Figure 5.1, where I focus on connections between people, I identified activities that strengthen structures and relationships between locations, building a shared context. The challenge for dispersed work in this regard is to understand that such a social context is present at locations, but does not develop entirely by itself in dispersed settings. A higher degree of intervention is required to bring people together. In other words, in dispersed settings, a different approach to establishing connections is required in order to provide enough of a shared context for specialization, from when R&D workers are co-located.

Management understands that for collaboration to take place, an interface between locations needs to be present. The set-up of such an interface is primarily determined by the roadmapping process (determining a new organizational structure), and aimed at establishing connections (i.e., initiating projects, allocating people). Engineers emphasized that, for dialogue and collaboration between scientists and engineers to occur in a dispersed setting, sufficient levels of familiarity, trust and social context are required. This means that management, besides building formal structures (i.e., establishing formal connections), is concerned with “facilitating an interface” between people from different units and different environments. Table 5.4 shows examples of activities that engineers and managers developed over time to establish connections. Specifically, management develops experience in making R&D professionals aware of the knowledge base of other units, convincing them of the advantages of knowledge integration, and building trust and a shared identity. My findings reveal that developing such an interface is a learning process, often involving trial and error. A lack of coordination will not support collaboration, but too much deliberate involvement will not benefit collaboration, or situated learning, either.
Table 5.4. Overview of the process of establishing connections

<table>
<thead>
<tr>
<th>Establishing connections</th>
<th>Definition</th>
<th>Exemplary quote</th>
<th>Examples of management interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creating and managing connections (social context) between units that are strong enough to enable heedful interrelating and situated learning.</td>
<td>“Well, maybe not even that you actually have to meet face to face with everybody separately—I think it is important that you’ve been there at their work place for more than one day.”</td>
<td>Deliberate approaches: - setting up structures - task allocation Emergent approaches: - goal-setting - storytelling - visits to the workfloor - exchanges of engineers - project transparency - integration courses</td>
</tr>
</tbody>
</table>

Managers explain that specialization is something that develops naturally in central settings, but for dispersed settings, a context for collaboration has to be created. This means that connections between people and practices in dispersed units need to be facilitated in order to create a shared social context (Figure 5.1). Engineers will start to value the need for collaboration when they have the opportunity to communicate and collaborate, and a process of sharing expertise, learning, and knowledge creation commences. Achieving such a context is seen as a prerequisite for collaboration in multisite projects, together with sufficient technological support for exchange. In dispersed settings, this social context cannot be created only by providing structure. A common way to facilitate stronger ties is by physically bringing specialists together. Engineers explain that this allows for close collaboration, provides the opportunity to build a shared context, and offers a sufficient level of trust for knowledge-sharing to take place. Another way to establish connections and create a social context is to develop common ground in different ways throughout the organization—for example, by spreading messages of shared goals and storytelling. One R&D director in the Netherlands explained how important it is to get familiar with “the other side,” and noted that a formal introduction is often not enough for collaboration between engineers:

“What is unknown, is unloved. I myself have had this same feeling. Before my first visit I did not understand many of their actions and thought they were doing things that didn’t make sense.” (R&D Director, Company A)
Establishing rich connections in distant relationships requires a combination of emergent and deliberate approaches, in which structure provides a basis for developing relationships. Multiple interviewees explained that a clear difference between central settings and dispersed settings was that in dispersed settings there was hardly any informal organization for coping with uncertainties or problems. For example, engineers and managers did not meet by chance and informally report on progress of their work, and work processes were not aligned by means of people’s physically working together. Interviewees explained how the informal structures that were sufficient when R&D was concentrated in a single location, became insufficient when R&D was dispersed across various locations. In response, many of the misunderstandings between R&D units were addressed by a higher level of formalization in ways of working and allocating responsibilities. This approach meant more rules and formalities in projects and for collaboration between engineers, which was found to interfere with actual R&D work.

A majority of the interviewees mentioned the problem that each unit in a dispersed collaboration assumed that its own dominant logic (Bettis & Prahalad, 1995), was the starting point for interpreting how a unit should function and how work should be done. Creating awareness of a unit’s own dominant logic and that of other units, and creating a shared identity, were found to support shared understanding. The following quote illustrates the influence of dominant logics on understanding between units:

“People who are doing one activity, think that this is the only way to do this, and this is right. And they have been working like that for a number of years. Now, a person of that level of expertise will really have a hard time if another person comes and then says “Hey, what you are doing is not right in the present scenario.” Sometimes it is very difficult to believe that because we believe that what we do is the only thing that is right. It’s human nature.” (R&D Manager in India, Company C)

In sum, both engineers and managers explain that the best thing management can do is to connect people, and make sure they can share. A social context is created by formally structuring connections (i.e., achieving integration), and furthermore by facilitating “soft” requirements such as trust, identity, and motivation.
5.4.4. Articulating content

On the right hand side of the model (focused on content), I provide insights into the tension between, on the one hand, making sure that knowledge creation can occur in practice (due to the creation of a shared context between dispersed settings) and, on the other, intervening in the knowledge-creation process in order to extract knowledge from practice. The challenge for managing dispersed work in this regard is to understand that both processes are vital for R&D, but that knowledge-integration efforts should not stand in the way of the specialization processes that are required for creating new knowledge, and that such specialization processes can indeed benefit organizational knowledge.

The process of articulating content involves both specialization and integration aims (see Figure 5.1). It entails taking what is learned and created in practice to a higher level in the organization, so it can be used in different contexts. I found several activities that are instigated to facilitate this process, summarized in Table 5.5. The activities are all part of a deliberate management approach, but are found to be most effective when the emergent nature of the specialization process is taken into account (as discussed below).

**Table 5.5. Overview of the process of articulating content**

<table>
<thead>
<tr>
<th>Definition</th>
<th>Exemplary quote</th>
<th>Examples of management</th>
</tr>
</thead>
</table>
| Articulating content | The process of making new knowledge visible to other parts of the organization | “A couple of times a year we arrange the program-management-team meeting. Program managers and innovation managers of groups who join the program come together, catch up, and discuss content. This way, we all get informed on what challenges are present. At the same time, I see these meetings as an opportunity to understand, ‘This is important in the US,’ ‘That is important in Shanghai,’ and so forth.” | - Communicating knowledge-integration objectives during the project  
- Scheduling time for knowledge integration  
- Meetings and discussions on project content and proceedings.  
- Managing patenting, codification and coordination  
- Workshops and presentations |
The aim of the process of *articulating content* is to integrate knowledge into the wider organization (establishing organizational knowledge), while the shared practice context in which specialization takes place is retained. Although managers are aware of the complexity of much of the newly created knowledge, and understand it is difficult to express it outside of its context, they explained that they strove for the best way to create organizational knowledge, and that documentation was one of their strategies. Interviewees mentioned that knowledge was extracted from practice by patenting and formalization, such as writing reports and having formal meetings. The difficulty in extracting specialized knowledge from its context is mainly that the knowledge becomes either too general, too specialized, or outdated, and because of this transformation, critical knowledge becomes less useful in other settings. Finding a balanced way to manage knowledge integration, while retaining the value of knowledge specialization, is therefore important.

Engineers explained that this extracted knowledge did not always support their practices in the organization and that they did not often use these reports. Sometimes process reports were looked into in order to understand choices in design, but often people involved in projects were directly contacted and new knowledge was shared through dialogue. As a specialist in company D points out: “People here call. A typical answer to your question is only two phone calls away,” meaning if you do not know the specialist you need in person, someone will direct you, and this usually takes one or two pointers.

From a practice perspective, engineers explained that activities they had to engage in that were being instigated by management to facilitate the process of *articulating content*, such as writing reports, were not part of their daily work in projects. When I asked how, for example, formal technical reports were being used, engineers explained that they did not often use these reports and felt that this activity took time away from the actual R&D work. They said they did understand the need for knowledge-sharing in activities such as workshops or presentations, but they made clear that it was not allocated to project time and clearly substituted for professional specialization (training, experimentation) and research time. The knowledge integration activities I identified (Table 5.5) were often not allocated to specific projects. Instead, these activities
informally took time from the next project, or from study time of the engineer at function. Often, there is no official (billable) time for knowledge-integration activities.

Engineers did understand the need for activities involving articulating content, but explained that such activities could both facilitate and hamper their work. Especially in the early phases of projects, where much research was done and opportunities were explored, concepts in projects were not that well defined. Engineers explained that setting goals for establishing organizational knowledge in this phase of projects could actually hamper their creative input, because they had to report development in progress, which was still difficult to define at this stage, and could hinder the actual development process. The effect of such formalization was that progress in projects was defined for the purpose of creating a report, and not so much for the purpose of knowledge creation. As a mechanical developer in company A explained:

“I often work in the first phase of projects, which is a really creative process. The moment you bring too much formalization into this phase, your creative process can become rigid. You will lose some degrees of freedom that you shouldn’t lose. The further you go down in the process, if then some function wants to take a different direction, then so much has become dependent, it becomes killing. You need the freedom. The freedom to discuss different directions in early phases of the project.” (Mechanical developer, company A)

At later stages in R&D (development), formalization and efficiency can play a more important role without directly interfering with the knowledge-creation process. Knowledge-integration activities can actually help determine the status of a project, and also identify points for further development. The following quotes show examples of how articulation of content through formalization and reporting can facilitate R&D work:

“In fact you write down what you know: the “recipe” of the existing product, test panels, test results, whatever reports included. Here, this is what we have, this is the status quo. You do this because when you have a review a year later in the project, we do not want to hear that another unit already did the same two years ago (reinventing the wheel).” (R&D manager, company 2)
“When it is time, we create a network of reports and wikis with all full explanations of how we came to certain preferences or choices. Our goal is to have the right info at moments that choices are on the table again. Then we know why we made decisions and whether the situation has changed.” (software and mechanical engineer, company A)

“Sometimes it is a good thing that the same is developed at different places. The result can be quite different. The important point here is to gear our programs to one another, so both can benefit. And therefore we need to know what is going on in projects.” (R&D manager, company C)

From the above it becomes clear that at early stages in the R&D process, integration activities can be counterproductive, but that, at later stages, these activities can actually facilitate R&D work. This indicates that timing is a very delicate issue in the introduction of effective knowledge-integration efforts in projects.

In sum, engineers explain how activities aimed at establishing organizational knowledge are important because they aim at extracting and retaining knowledge from practice. The challenge of obtaining organizational knowledge is found to be managed by the process of *articulating content*, but it needs to take into account both integration and specialization objectives to be effective. In turn, organizational knowledge is used as input for the roadmapping process. Figure 5.1 shows how each challenge is managed by a process, and how the implementation of each process provides a basis for another process. This interrelatedness between challenges and processes, as well as between specialization and integration, will be elaborated on next.

5.4.5. Balancing specialization and integration in dispersed settings
Developing capabilities to balance specialization and integration efforts is something organizations do over time, by understanding how different management activities and R&D processes interrelate. The model in Figure 5.1 provides represents this interrelatedness.

The challenges identified in Figure 5.1 (the four cells) are interrelated and show mutual reinforcement, as they all build on the results of the accompanying coping processes. Throughout the findings, I have introduced Figure 5.1 with a somewhat cyclic character. For instance,
situated learning can be improved if a shared context is facilitated by achieving structure and a
d social context. The development of an interface creates new connections, via which practices are
shared. This shared social and practice setting enables the actual R&D work to take place. The
process of articulating content is in turn aimed at tapping into the results of the processes of
situated learning and of integrating more general knowledge into the organization. Next, adequate
knowledge integration provides the basis for roadmapping, because what the organization knows
(and needs to know) strongly determines the future direction for R&D. This direction is an
important shaping condition for new connections (achieving structure), on which the process of
establishing connections builds.

In time, these processes become more and more routine for management, as they gain
experience in dealing with knowledge-integration issues. If one or more of the processes is not
adequately developed, it will affect the other processes. An example of how the four processes
interrelate is the Graphic case (chapter 3). To recall, Graphic’s corporate R&D management
acquired a small subsidiary in Canada specialized in state-of-the-art printing technology,
reflected in the Jupiter line of image printers. Nine years after the acquisition, the Mesa project
was initiated by corporate R&D in the Netherlands, which was to be the first large joint project
involving, and combining knowledge from, both units. The project revolved around the use of
Canada’s Jupiter printing technology on top of an automated print table designed by the Dutch
unit. To assess the compatibility of the two technologies, a number of visits were made by
management and lead engineers from both sides, and the Canadian unit started to theoretically
integrate technologies from both units. Here, the two groups encountered the first hurdles. Both
units had developed their own specialized technologies. It turned out they had developed
incompatible design systems, and that the Canadian unit did not have access to the intranet at the
Dutch headquarters. The two units had difficulty collaborating. Connections did not get off the
ground and, after some time, the units found that they lacked sufficient common ground to fully
understand each other’s views on the project and its technical requirements. Despite considerable
efforts in terms of facilitating the collaboration and integrating knowledge from both units, it
turned out to be too difficult to create enough common ground to allow for this form of combined
innovation. Subsequently, after 18 months of collaboration efforts, management from both units
decided to discontinue the project. Respondents gave many different reasons for the cancellation of the project, but the general feeling was that “it was just not working.”

One of the central reasons why “it didn’t work” was that corporate R&D management failed to integrate the highly specialized knowledge held by both units, i.e., achieving integration between units. As both units had been working independently of each other for a long time, they had both developed deeply specialized knowledge, as well as their own way of working on their part of the project. Following Figure 5.1, achieving situated learning between the units turned out to be a very challenging task—this is exactly the process over which management can exert the least control. The units did not have a sense of a shared goal, let alone a shared identity. Although management did attempt to establish integration between the units, this was not sufficient for actual collaboration to occur. In terms of a more deliberate approach to connect the units, information and communications technology was not adapted well enough to facilitate joint specialization. Instead of focusing on establishing a shared social context as a condition for joint action (i.e., integrating the Dutch table technology with the Canadian printing technology), corporate R&D management primarily focused on the shared practice context – not by facilitating this in an emergent way, but by deliberately defining a shared-project context in a top-down fashion. That is, corporate R&D management focused more on the content (the need to integrate the two technologies) than on the connections between R&D professionals from the two units. Because the project was cancelled before sufficient levels of common ground and joint specialization were reached, the actual situated-learning process, which could have resulted in a combined innovation, did not take off. This in turn prevented the articulation of content, because no new knowledge was created.

Management as well as engineers at Graphic emphasized the interrelatedness between specialization and integration efforts, denoting the importance of first realizing “integration between units” before joint specialization could take place. The efforts towards collaboration, it seems, were too tightly focused on deliberate interventions in the content (a top-down project definition that was all but forced on the Canadians), and too focused too little on emergent approaches towards achieving integration. Ultimately, the Graphic case illustrates the interrelatedness between specialization and integration efforts, and some emergent processes
needed for collaboration between units that are the most difficult to identify, deliberately manage, or monitor. It also shows that these are especially crucial to let R&D get the job done (Dougherty, 2001).

5.5. Discussion
This chapter offers insights into the tension between specialization and integration in dispersed R&D settings. I propose a model that builds on the notion that specialization and integration processes are strongly interrelated, and have the potential to both conflict with and mutually reinforce one another. The distinction between managing connections and managing content enabled me to identify more-specific challenges regarding the management of specialization and integration. Subsequently, I identified the processes of establishing connections and articulating content, thus yielding insights into how both specialization and integration can be managed in relation to one another at different organizational levels.

Although the somewhat cyclical character of this model implies that there is no clear beginning or end, my findings indicate that, after the strategic planning process of roadmapping, management interventions in the dispersed R&D process tend to focus on building relationships and facilitating an interface, i.e., on establishing connections. Management generally shows an awareness of the fact that actual situated learning among R&D people is not to be directly interfered with. They see their role primarily in terms of creating the conditions for this process by bringing the right people together. The processes that take place between these people (situated learning) are not subject to management interventions, but the knowledge that results from these processes is, to a certain extent: managers do see a role for themselves in the process of articulating content, but they show an awareness that this requires a delicate balance between the emergent character of the knowledge-creation processes, and the interest in integrating the outcomes of these processes. The strategic process of roadmapping is a typical management process, in which organizational knowledge derived from practice is used as input to decide on future directions for R&D. So, in general, the core knowledge-creation process of situated learning is one in which management tends not to interfere, aiming instead to create the optimal
conditions for this process by establishing connections, articulating content, and engaging in roadmapping.

5.5.1. Theoretical implications

While most theory on specialization and integration focuses on the balancing act between the two strategies on a managerial level, this study describes the tension between specialization and integration from a more practice-based perspective, including micro-level processes in actual R&D work. My findings offer insights into the challenges associated with balancing specialization and integration on a managerial level, and they suggest how these challenges should be coped with by describing coping processes. Crucially, I find that management’s role is primarily focused on creating conditions for the process of situated learning. Situated learning itself is emergent, and any deliberate interventions are aimed at creating conditions for this process to take place: establishing sufficient connections between professionals, and integrating the knowledge resulting from this process on an organizational level, thus institutionalizing and validating the outcomes of the process. This relates closely to work on “semi-structures,” which implies that organizations have structures that can be partly determined in advance and have clear intervals and goals, and that also contain an unstructured part in order to allow the freedom that is crucial for knowledge creation and adjustment in R&D work itself (Brown & Eisenhardt, 1997). I contribute to the literature on semi-structures by unraveling the tension between specialization and integration in practice, and by elaborating on actual management processes that take place across both efforts.

Second, taking the model through different projects reveals the development of the four processes, which in the beginning may be a process of trial and error itself, but which in time and through experience will become more familiar and routine. This finding resonates with other work on developing capabilities in innovation. Brown and Eisenhardt (1997), for example, describe how organizations become successful in managing their portfolios, by creating “links in time,” developing their understanding of innovation processes, and becoming more pro-active in coping with challenges as opposed to reacting and following up afterwards. Staudenmayer, Tyre and Perlow (2002) describe, from an opposing point of view, how necessary the experience of
time is to understanding organizational capabilities and developing routines. They illustrate how temporal shifts, or “changes in rhythm,” are fundamental to triggering, coordinating, and reallocating in organizational development, and how this in turn nourishes the ability to create the routines by which R&D persons detect and respond to challenges in the field. Likewise, Feldman and Pentland (2003) discuss routines as enablers of ongoing performance, and as developing capabilities for an organization to become more adaptable or flexible based on prior experience. Grimpe and Kaiser (2010: 1491) argue that “experience might even substitute for the tacit knowledge component that is difficult to transfer between units.” In this respect, my proposed model in the context of dispersed R&D settings evolves from a process of hitches and trial and error into a process in which the awareness and experience managers have serve as input for coping with future challenges. In this way, I contribute to the literature on organizational learning (Brown & Eisenhardt, 1997; Feldman & Pentland, 2003) by elaborating on the development of capabilities and routines for management in managing knowledge in dispersed R&D settings (e.g., Argote & Ingram, 2000; Lave & Wenger, 1991; Pisano, 1994; Sole & Edmondson, 2002). Specifically, I introduce a new model that depicts what management challenges exist in dispersed R&D settings, and how such challenges are coped with in a dynamic way by elaborating on the interrelatedness between several challenges and coping processes. With this model, I provide a broad overview of what dispersed R&D management entails, something that has not been done before.

### 5.5.2. Practical implications

In terms of practice, the main implication from this study is in the dual role management needs to play in managing both “connections” and “content.” This role has both deliberate and emergent aspects, but in practice the latter are often overlooked, because many of the emergent processes that feed relational embeddedness occur naturally when projects are centrally organized, but need more facilitation when they are dispersed. In the latter case, the natural tendency for management is to emphasize deliberate interventions in order to compensate for the complications that result from dispersing R&D—for example by allocating tasks and responsibilities in a top-down fashion. The downside of this approach is that it often creates more distance between managerial levels and, in this case, between different locations. Even more facilitation is needed to create an
interface in which collaboration can take place. Managers facing the challenge of dispersed R&D settings should be aware of this tension, and strive to find a balance between deliberate interventions and a more “hands-off” approach.
The aim of this dissertation has been to provide insights into the management of knowledge in dispersed R&D settings. Using a practice-based and a knowledge-based perspective, I have analyzed my research subject from different angles. This has resulted in four studies that show how both perspectives on managing knowledge exist in practice, and how management in the organizations I looked at is trying to address the objectives of fostering both specialization and integration.

This chapter reviews the main findings and presents an overall answer to the research question. I then discuss theoretical and practical implications and offer suggestions for further research. Table 6.1 provides an overview of the studies and the main contributions.
Table 6.1 Main findings per chapter

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Main contributions (findings, response to overall research question, theoretical implications, practical implications)</th>
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<tbody>
<tr>
<td>2.</td>
<td><strong>Knowledge integration in global R&amp;D networks</strong>&lt;br&gt;Chapter 2 builds on the Argote et al (2003) model for analyzing knowledge-management research, and reports on factors influencing knowledge integration. At a <em>unit level</em>, dominant logics and cultural awareness are found. At a <em>knowledge level</em>, common knowledge and the embeddedness of knowledge are found to be essential themes. At a <em>relational level</em>, relational embeddedness and structural embeddedness are identified. The study identifies challenges specific to knowledge management in dispersed R&amp;D at three different levels, and elaborates on deliberate and emergent approaches to managing these challenges. This contributes to existing work by 1) identifying the main factors influencing an organization’s ability to organize for dispersed collaboration, and 2) revealing the need for different approaches to managing knowledge in dispersed settings.</td>
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<tr>
<td>3.</td>
<td><strong>Boundary objects in new joint fields: routines, bias, and incompatibilities in dispersed R&amp;D settings</strong>&lt;br&gt;Chapter 3 reports on a case study on a dispersed project between two international locations in which a boundary object, useful for understanding and collaborating between teams, was obstructing collaboration in practice. The study identifies the challenge of creating an adequate practice context for collaboration, and provides useful examples of how specific tools and contexts can influence the actual collaboration between dispersed settings. This chapter contributes to literature on dispersed R&amp;D work, by explaining from a practice-based perspective how boundary objects can become embedded in existing practices and routines, and therefore become impractical in new settings. The chapter also contributes to the literature on new joint fields by discussing how they can become filled with boundary objects-in-use from other fields, and provides an understanding of what this entails for intra-organizational collaboration.</td>
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<tr>
<td>4.</td>
<td><strong>Knowledge Pollination: Facilitating organizational learning in geographically dispersed settings</strong>&lt;br&gt;Chapter 4 unpacks the nature of R&amp;D work and reports on the work of engineering consultants working on different geographical locations. The study identifies the challenge of integrating knowledge that is embedded in different local contexts and unravels the practices through which engineering consultants play a crucial role in knowledge integration at inter-unit and organizational levels. More generally, the study reveals how, from a practice-based perspective, knowledge is disseminated through primarily emergent practices. The chapter contributes to work on dispersed collaboration and network research by 1) introducing the concept of knowledge pollination to describe how these engineering consultants embed, disembed, and re-embed knowledge between different settings and their network, and 2) elucidating how this activity contributes to the learning and retention of knowledge in the organization.</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Managing specialization and integration in distributed research and development</strong>&lt;br&gt;Chapter 5 takes a managerial perspective on managing knowledge. By including insights from a practice based perspective, it discusses the tension between specialization and integration, and empirically investigates how this tension is managed in practice.</td>
</tr>
</tbody>
</table>
The challenge identified in this chapter is the balancing act between specialization and integration at different levels. Furthermore, the study identifies knowledge-management processes and specific activities adopted by management in order to pull off this balancing act. The chapter contributes to the literature on managing R&D work by 1) explaining integration and specialization practices from both a knowledge and a relationship point of view. Both views are presented in a model, which gives a clear understanding of the nature of R&D work and of how this is managed, and 2) identifying and describing two processes that balance specialization and integration efforts, namely by establishing connections and articulating content.

### 6.1 Main findings per chapter and the answer to the overall research question

**Chapter 2: Knowledge integration in global R&D networks**

Chapter 2 is the exploratory study of this dissertation in the sense that it builds on a general research model for analyzing knowledge-management research as applied to the field of dispersed R&D. The research objective that guided this study is to explore which factors have an influence on the process of integrating knowledge between R&D units, and how these factors are dealt with in practice. Using the Argote *et al.* (2003) research model, and collecting interview data on managing knowledge at the level of the R&D unit, the knowledge involved, and the relationships between units and the wider organization, the analysis revealed several factors influencing the knowledge-integration process.

The contribution of the study is twofold. First, it complements previous studies on knowledge management in dispersed R&D by identifying challenges for management at three different levels. Based on interview data, the study describes each challenge in the context of dispersed R&D settings, and provides coping mechanisms that managers use. Second, for each level of analysis: the unit-, knowledge-, and relationship level it identifies different approaches to management. On the one hand, interviewees identify several deliberate coping mechanisms, such as providing structure and enhancing the visibility of work procedures. On the other hand, a more emergent approach to managing knowledge prevails, in which the different challenges are considered in relation to each other. The study addresses the importance of considering the actual practice setting in which R&D takes place, in order to understand how different challenges interrelate. The study also addresses several emergent concepts, such as embeddedness and various management approaches, which are a point of departure for the following chapters.
Chapter 3: Boundary objects in new joint fields

Chapter 3 builds on the findings of chapter 2 on the need to further explore R&D in practice settings, and reports on an in-depth case study of a collaborative project between a Dutch and a Canadian R&D unit of an MNC specialized in print technologies. The case study describes how collaborative tools that have historically been used in different contexts, although important in facilitating collaboration and shared understanding of technologies, can be difficult to transfer to shared practice settings. Specifically, the case study illustrates how the local embeddedness of boundary objects in specific practices and routines can have a strong influence on their functioning as boundary objects within new joint fields in dispersed R&D settings. The findings of the study are illustrated by the use of 3D CAD software and wikis. I discuss how some of these boundary objects were highly successful in bridging boundaries between dispersed R&D teams, while others actually hindered the establishment of a shared practice context.

The analysis highlights the importance of the presence of a shared social and practice context to share tacit knowledge, experience, and know-how on the development of new technologies. Since in dispersed settings this is difficult to realize, it is helpful to elaborate on how boundary objects can facilitate or hinder the establishment of such shared contexts. The contribution of this chapter is twofold. First, it shows that the historical use of boundary objects with similar functions in local settings can play an essential role in the adaptation of those objects to new shared settings, such as dispersed collaborations. Second, the study shows how a new project environment does not imply, by design, that this environment is entirely neutral to all parties. Adopting collaboration tools from one of the groups involved can have beneficial as well as detrimental effects on the creation of a shared social and practice context.

Chapter 4: Knowledge pollination: facilitating organizational learning in geographically dispersed settings

The study in chapter 4 addresses the necessity and complexity of creating, and coping with, the local embeddedness of knowledge. Based on a case study on the role of internal engineering consultants in an MNC specialized in energy technology, a process of knowledge pollination is identified. The chapter reports on how an established yet flexible network of knowledge workers can help in overcoming the local embeddedness of knowledge by pollinating knowledge across
different settings. Engineering consultants temporarily embed themselves in local settings, transfer the knowledge they already carry with them, and collect new knowledge from each setting to take to the next local setting.

The study contributes to the literature by introducing the concept of knowledge pollination, thereby illustrating an organizational learning process that is not so much deliberately initiated by the organization itself, but that emerges from other processes—organized learning, learning in practice, and transactive memory—and is enhanced by the way internal engineering consultants work in geographically dispersed settings. Furthermore, the study offers novel insights into the embeddedness of knowledge. It provides a micro-level perspective on how engineers develop experience, and connects this to the macro-level perspective of how engineering consultants can facilitate coping with embeddedness.

Chapter 5: Managing specialization and integration in dispersed R&D
The study reported on in chapter 5 focuses on the tension between specialization and integration in dispersed R&D. On the one hand, there is the organizational aim of specialization in certain knowledge domains, through dispersed R&D units as centers of excellence. This creates the local embeddedness of knowledge and practices. On the other hand, organizations aim to integrate useful knowledge into the organization so that it can be recombined and re-used in other parts of that organization. By taking into account processes that allow for specialization such as situated learning, and processes that facilitate integration such as roadmapping, the study identifies several challenges that deal with both specialization and integration. These challenges are described, and are illustrated with examples from practice on how to manage the delicate balance between specialization and integration.

The main contribution of this study is the overview that I present of, on the one hand, the processes of knowledge specialization and integration and, on the other, the relationships between these processes in practice. While in previous literature the tension between specialization and integration is approached from a purely managerial perspective, this study also includes micro-level processes in order to provide a richer understanding of the ways in which a balance is found between specialization and integration. It unpacks in detail what engineers and specialists require for collaboration (which results in situated learning and specialization), and
how knowledge-integration efforts can hamper or facilitate this process. In addition, the study reports in detail on the interrelatedness between several integration and specialization processes, by emphasizing the dynamic character of managing dispersed R&D across space and time.

Answering the main research question
The main research question of this dissertation is: “What are the knowledge-related challenges that firms with dispersed R&D locations face, and how are these challenges dealt with in practice?” Each separate study in this dissertation represents an effort to approach this main research question, from different angles.

In Table 6.2 I have identified three main challenges, namely managing the tension between specialization and integration, managing embeddedness, and managing knowledge-transfer mechanisms. By combining two different views of knowledge (knowledge-based and practice-based), I was able to identify important processes and areas of attention for management which have until now not been discussed in the R&D literature. The challenges identified are unique to the field of dispersed R&D in the sense that they 1) directly represent the complexity of knowledge involved in R&D work, 2) are intensified by the geographical dispersion of R&D, and 3) require a different approach than is required for more-centrally organized R&D settings.

For the second part of the research question, namely how challenges are dealt with in practice, the four studies provide many examples of how organizations cope with managing the three challenges. As we look at the findings of each study, and at overlapping themes that emerge from the data, it is evident that there is not one specific answer for each challenge that will provide organizations with the key to successful dispersed R&D collaborations. As the literature has pointed out, factors such as the ability to decouple technologies or projects, the kind of knowledge involved, and the nature of the collaboration all have a strong influence on the ease of dispersed collaboration (Birkinshaw 2002; Lahiri 2010). However, besides concrete actions that organizations undertake, each study also discusses some more abstract concepts that not only straddle several coping mechanisms, but also shed light on how coping mechanisms relate to each other. As an answer to how challenges are dealt with in practice, I created an overview of these more abstract insights that have been identified, and which I have called knowledge-management insights. This overview can be found in Table 6.2. Below I briefly discuss the three main
challenges. The next paragraph on theoretical implications elaborates on the main findings in this table, and how these contribute to the existing literature.

**Table 6.2. Overview of identified challenges and KM insights**

<table>
<thead>
<tr>
<th>Challenges identified</th>
<th>Knowledge management insights (and corresponding chapters)</th>
</tr>
</thead>
</table>
| Managing the tension between specialization and integration (chapter 3, 5) | Understanding the nature of R&D work, processes of establishing connections and articulating content, and assessing requirements for specialization practices (social and practice context)  
  - Identified specific activities that require alignment from both specialization and integration perspectives (chapter 5)  
  Understanding how different levels of specialization and integration (intra-unit, inter-unit, organizational) relate and change in dispersed settings.  
  - Illustrations of how intra-unit specialization and inter-unit specialization/integration relate in a practice setting (chapter 3)  
  - Explication of how integration on a “connection” and a “content level” relate to the specialization process (chapter 5)  
 Deliberate and emergent approaches to managing knowledge.  
  - Considering deliberate and emergent approaches to establishing connections and articulating content (chapter 5) |
| Managing embeddedness (chapter 2, 3, 4, 5) | Understanding embeddedness from specialization and integration objectives  
  - Concerning the design of new joint fields and knowledge-transfer mechanisms as boundary objects (chapter 3)  
  - The processes of situated learning and articulating organizational knowledge (chapter 4)  
 Deliberate and emergent approaches to managing knowledge  
  - Concerning dominant logics, cultural awareness, common knowledge; and knowledge, relational and structural embeddedness (chapter 2)  
  - Regarding specialization and integration processes (chapter 5)  
 Understanding how R&D workers can provide emergent knowledge-transfer mechanisms to integrate knowledge in the organization.  
  - Engineering consultants disembed and re-embed critical knowledge throughout different projects (knowledge pollination). Combining formal learning, informal learning, and transactive memory (chapter 4) |
| Managing knowledge transfer mechanisms (chapter 2, 3, 4) | Understanding differences between dispersed settings on different levels  
  - Differences at a unit, knowledge and relational level, providing specific points of attention (chapter 2)  
 Understanding routines and specific work practices particular to specific knowledge (embeddedness)  
  - Considering new joint fields as shared practice settings, and boundary objects for collaboration (chapter 3)  
 Understanding less-explicit knowledge-transfer mechanisms  
  - The process of knowledge pollination as a knowledge transfer mechanism (chapter 4) |
The challenge of managing the tension between specialization and integration

Previous literature discussed specialization and integration as objectives for the R&D organization. Striving for both objectives simultaneously is described as a challenging task, since the two processes carry conflicting views in terms of knowledge. The management challenge here is to manage specialization and integration at the same time, while aiming to realize both processes effectively. For dispersed specialization to take place, some form of integration between local settings needs to be present. For the development of more organizational knowledge, other forms of integration are needed. The difficulty here is for management to determine how to balance such integrative aims with the specialization process.

The challenge of managing embeddedness

The concept of embeddedness became a central theme in all four studies. Embedded knowledge is shown to be of utmost importance for organizations, because it is learned, produced, and shared in practice, difficult to explicate and transfer, and can therefore be of great competitive value to R&D organizations. The management challenge here is to understand the complex situation of knowledge that is embedded in people, practices, technologies, and contexts, and to cope with the difficulty of sharing such knowledge in geographically dispersed settings. The challenge is especially great because embedded knowledge is ideally shared face-to-face, through learning by doing together in practice. This is something which is seldom possible if people do not work physically together.

The challenge of managing knowledge transfer mechanisms

A third main challenge I identified is the ability to manage knowledge transfer mechanisms. Such mechanisms play a key role in the knowledge flow of organizations, especially in dispersed settings where the social and practice context is not automatically present (due to physical distance). The managerial challenge here lies in understanding what knowledge is involved in different contexts, and determining how such knowledge can be shared within the organization. The findings of this dissertation elucidate how management can be aware of differences between the contexts in which knowledge resides, in order to select adequate knowledge transfer mechanisms. It also elaborates on several formal and informal knowledge transfer mechanisms covered by the organizations under study.
6.2. Theoretical implications

In this section, I discuss the implications for theory on managing knowledge in dispersed R&D settings. I also discuss the implications for concepts that have emerged in separate studies of this dissertation and which, taken together, provide new insights for literature. By introducing the tension between specialization and integration as a theoretical starting point for the empirical studies in this dissertation, many new insights specific to dispersed R&D management could be explored. The implications closely relate to the three main challenges identified, covering specialization and integration in dispersed R&D, knowledge embeddedness, and knowledge transfer mechanisms in dispersed settings.

6.2.1. Specialization and integration in dispersed R&D

The two processes of specialization and integration are frequently discussed in previous literature (e.g., Almeida & Grant, 1998; Chiesa, 1996; Postrel, 2002; Teigland et al., 2000), but often with a clear focus on one of the two processes. In this dissertation I have not focused on either of the processes separately, but on the interrelatedness between the two. The studies presented are among the first to provide in-depth empirical evidence on how specialization and integration processes are associated in practice in dispersed settings. Specifically, I identified situations where both processes were present and focused on management’s and engineers’ practices in order to obtain an understanding of how such interrelatedness is dealt with. For instance, chapter 3 (on boundary objects) provides a practical example not only of how the specialization of two separate units makes it difficult to collaborate (i.e., integrate), but also of how integration decisions affect whether specialization between units can take place. The study identifies the ways in which shared contexts and tools can influence this tension, both positively and negatively. Chapter 4 (on knowledge pollination) provides another practical example of how engineering consultants provide integration between dispersed settings, namely by understanding specialization in different settings, and by implementing their own specialized knowledge in different settings. Chapter 5 elaborates on this tension in detail and, by identifying processes that relate to both specialization and integration, provides more general points of attention drawn from an analysis of multiple organizations.
This dissertation provides two theoretical contributions to my understanding of this subject. First, I discuss theory on the nature of R&D work (being integral, situated and emergent), and argue that dispersed R&D settings increase the tendency to specialize on a local level, while decreasing the ability to integrate knowledge. Elaborating on this increased tension between specialization and integration, the empirical findings provide evidence for this increase by, for example, increasing differences between units (chapter 2), otherwise naturally organized processes that require an alternative approach when organized in a dispersed setting (chapter 4), and by an increase in deliberate management towards the knowledge-creation process (chapter 5). By taking a practice perspective on specialization and integration efforts in R&D collaborations, I was able to determine that these findings have in common the lack of a shared social and practice context in which to collaborate. The contribution here lies in the notion that a shared context can help organizations cope with the tension between specialization and integration. Within a shared context, interaction in practice can work as a mechanism to steer both specialization and integration (Brown & Duguid, 2001). This occurs emergently within the work context itself, which creates several advantages. First of all, specialization and integration processes that occur naturally in practice show less tension than organized processes (e.g., Huang and Newell, 2003). This is mainly because both processes emerge from the actual R&D work, which entails both a situated and an integral nature (Dougherty, 2001). Both specialization and integration are steered by problem solving in R&D work itself, instead of being steered by separate organizational objectives (local specialization and organizational integration). Second, if specialization and integration can occur and emerge more naturally in the practice of work, then this is a partial substitute for more designated management interventions (e.g., Van den Hooff & Huysman, 2009). This is more evident in centrally-organized settings, but findings show that emergent specialization and integration also exist in dispersed settings. Third, interaction between specialization and integration in practice can actually enhance both these processes, because a vital combination of the two creates new knowledge, as the nature of R&D work implies (Dougherty, 2001; Kogut & Zander, 1993). The findings of this dissertation imply that R&D work benefits from a healthy interaction between specialization and integration in practice, and that a focus on a shared context is essential here. Although shared contexts have been discussed in previous literature on dispersed project management (Gerybadze & Reger, 1999; Hinds and Mortensen, 2005; Sole and
Edmondson, 2003), the concept has not been related to the tension of managing specialization and integration. Hence, a shared social and practice context can directly influence the tension between specialization and integration, and is therefore a key point to consider when dealing with this challenge.

The second theoretical contribution is as follows. I have discussed the concepts of knowledge specialization and integration on different levels, which contributes to my understanding of the link between corporate R&D management with R&D management on middle and lower levels in the organization (e.g., Hitt, Ireland, Camp & Sexton, 2001; Lane and Lubatkin, 1998; Smitz & Strambach, 2009; Strambach & Clement, 2012). Specialization is not only discussed on a unit level, as a process that is embedded in its context for the creation of specialized knowledge (e.g., Brusoni, Prencipe & Pavitt, 2001; Nerkar & Paruchuri, 2005; Roth 2003), but also at an inter-unit level in collaborative settings between units (e.g., chapter 3). While the former level of specialization requires a fair degree of laissez-faire management (because much of the specialization process emerges in practice, and knowledge creation is something that happens through the interaction with practice), the latter form of specialization requires more involvement in order to create a social and practice context. This involvement should mainly be aimed at establishing connections, and not at defining the content of the collaboration – this is still something that should emerge within this shared practice context. Integration is discussed at a unit level (chapter 2, 3), an inter-unit level (chapter 2, 3, 4, 5) and an organizational level (chapter 4, 5). At a unit level, knowledge is integrated through both formal and informal activities, while at an inter-unit level, informal activities (such as spontaneous discussions and learning who knows what) are less evident. Taking into account that inter-unit integration of knowledge is required for the creation of a shared practice context (in order to combine knowledge and collaborate between units), and also considering the lack of informal communication opportunities in a dispersed setting, this means that inter-unit integration must be managed differently from knowledge integration on a unit level. The studies in this dissertation elucidate how such inter-unit integration can be managed, while retaining the opportunity for specialization. Then, on an organizational level, knowledge integration is more remote from specialization practices. It can have negative effects on the emergent nature of R&D work if it interferes with specialization and integration processes on unit or inter-unit levels. Accordingly, these insights have not been unpacked in this
way before and provide new understanding for managing dispersed R&D in general. This understanding implies that 1) future studies that analyze multiple levels of R&D management must be aware of these interacting fields, because specialization and integration processes affect each other on different levels (e.g., Berggren, Bergek, Bengtsson, Hobday & Söderlund, 2013, Crossan & Apaydin, 2010; Meyer, Mudambi & Narula, 2011), and 2) managing R&D involves a combination of different approaches (i.e., a balancing act) towards coping with both processes in practice (e.g., Gassmann & Zedtwitz, 2003; Van den Hooff & Huysman, 2009).

6.2.2. Embeddedness of knowledge
As pointed out, knowledge can be deeply embedded in local settings, work practices, and people, and is impossible to exist outside of its context (Cook and Brown 1999; Galunic & Rodan, 1998; Howells, 2000; Lam 1997; Lave and Wenger 1991; Orlikowski 2002; Tyre and Von Hippel 1997). The concept of the embeddedness of knowledge is related to the concepts of specialization and integration, in the sense that embedded knowledge is often specialized knowledge, and organizations struggle with how such valuable knowledge can be transferred and shared (integrated) with the organization. This embedded knowledge, or knowing, derives from people making informed decisions based on the specific circumstances of a context. It is produced in practice and is therefore often tacit, specific, and embedded in different working contexts, such as physical processes (technologies, procedures), social communities (people, occupations, projects), and broader industry contexts (Hsiao, Tsai & Lee, 2006; Lam, 1997; Maskell & Malmberg, 1999; Orlikowski, 2002; Tyre & Von Hippel, 1997). Being produced in a highly interwoven context (e.g., Gertler, 2003), such knowledge is fragmented and embedded within several elements in its context, making it useful and understandable in that particular context. It is sticky to where or to whom it is created, making it unique and potentially valuable for organizations to exploit as a resource (Gertler, 2003; Szulanski, 1996). The concept of embeddedness was derived from findings in three of the studies in this dissertation, and became the central research subject of chapter 4. The four studies taken together provide implications for theory on embeddedness.

First, although the concept of embeddedness in relation to managing knowledge has been given little attention in previous studies, those studies that did address the concept as a primary
research subject present interesting insights to which this dissertation can contribute. Hsiao et al (2006) for example, argue that difficulties regarding transfer, coordination, and reuse of knowledge should also be analyzed in respect to the work practices and contexts of knowledge workers. They investigated two different expert groups using the same knowledge transfer system, and found that field workers, who performed in highly dynamic and different embedded contexts, did not consider the system useful. They found the knowledge derived from the system too fragmented (no more than a snapshot) to be applicable to the holistic troubleshooting process in their highly embedded work contexts. The other group of equipment engineers, who performed in a more stable and standardized context, found the knowledge transfer system much more useful as it was better suited to facilitating their work. Hsiao et al (2006)’s study addresses the importance of how the transfer of knowledge is affected by the embeddedness of such knowledge in work contexts. This dissertation addresses embeddedness in the context of dispersed R&D settings, involving highly intensive knowledge and different practices and work contexts. Chapter 3 provides findings comparable to Hsiao et al (2006) on the understanding of embeddedness for decision-making on collaboration tools. Chapter 4 elaborates on this by starting off with embeddedness as a challenge for dispersed R&D. It reveals mobilizing experts as an alternative way of coping with embeddedness, due to their ability to make sense of embedded knowledge (the examples are further elaborated on in the next paragraph). These findings give insight into how the context of R&D work is actually a part of knowledge itself and should be included when coping with knowledge transfer difficulties, particularly in dispersed and highly intensive knowledge contexts (Gertler, 2003; Hsiao et al, 2006; Lervik, 2008). The findings also extend the work on managing embeddedness by elaborating on how embedded knowledge can be transferred and reused in different contexts, while keeping that “usefulness” it has in its created context (e.g., Orlikowski, 2002; Tyre & Von Hippel, 1997). The dispersed R&D setting in which this research is conducted provided a context in which highly intensive and complex knowledge resides. Similar to the field engineers’ work context of Hsiao et al (2006)’s study, this is a highly dynamic field. The results indicate that managing embedded knowledge in dynamic fields is not a matter of managing knowledge itself. As can be seen in chapter 4 and 5, embedded knowledge bridges different contexts through connections between people and locations that carry such knowledge, rather than by twisting knowledge into a form that is transferable outside of its context. This steers the focus
of managing embedded knowledge away from knowledge itself, and more towards managing the practices that entail R&D work (e.g., Hansen, Nohria & Tierney, 2000).

Related to the usefulness of embeddedness are the findings of a recent study by Andersen (2013), who discusses the benefits of embeddedness and costs of over-embeddedness, and questions the “predominant view of the two to be absolute and mutually exclusive and as either increasing or mitigating performance” (p.147). She argues that whether embeddedness positively influences performance depends on the objective at hand. This dissertation contributes to literature on embeddedness in the sense that it illustrates that embeddedness can be favorable and unfavorable with both theory-based and practice-based arguments. More specifically, I explain embeddedness as a concept derived from the practice-based perspective, and combine it with specialization-integration concepts stemming from the knowledge-based view. By doing this, I relate the concept of embeddedness – often described as a circumstance in practice, or something that just happens in the course of work – to clear organizational objectives. This theorizing contributes a more managerial perspective on how to approach embeddedness to the embeddedness literature. In chapter 4, for example, I describe how embeddedness is favorable for specialization and situated learning within locations, and how it can be unfavorable when the organization wants to organize for knowledge integration to higher levels in the organization (e.g., for roadmapping efforts). More generally, this study shows that when coping with embeddedness, both specialization and integration objectives must be considered. From a specialization perspective, the degree of the embeddedness of knowledge, people, and practices at locations can be quite high: relational and structural embeddedness within one location reduces search and coordination costs and positively affects deep interaction between people (experts), while also creating opportunities for knowledge-creation and innovation (Brown and Duguid, 2001). This finding shows how more deliberate approaches to managing R&D, such as structuring relationships within collaborations, are coordinated in such a way that situated learning can take place. By including the knowledge-based view concepts into practice based literature on embeddedness, I define in more detail the “different objectives” regarding embeddedness or over-embeddedness that Andersen (2013) is referring to. By relating it to these concrete R&D objectives I further unravel the concept of embeddedness by giving a more concrete explanation. More specifically, this relation elucidates how commonly conflicting views on embeddedness can be viewed as specialization and/or
integration objectives, and how such different views can be aligned and coped with. This provides the embeddedness literature not only with a detailed description of the phenomenon, but also with a management perspective of how embedded knowledge can be managed and exploited as a resource in the organization (Gargiulo & Benassi, 2000; Meyer et al, 2011; Nielsen, 2005; Sydow, Lindkvist & DeFillippi, 2004).

6.2.3. Knowledge management and knowledge transfer mechanisms

The findings in this dissertation imply that standardized transfer mechanisms that are assigned to facilitate knowledge integration, without considering the locally embedded context in which knowledge is created, appear to be ineffective in dispersed settings (McIver, 2013; Thompson & Walsham, 2004). Furthermore, when dispersed R&D organizations consider knowledge transfer mechanisms, much of the focus is on ICT tools (Howells, 1995; Roberts, 2000). The contribution of my work lies in the overall conclusion that ICT tools are only a part of the knowledge transfer mechanisms. Knowledge is embedded in a whole range of tools, formal and informal processes, and the careful consideration of interrelated contexts, practices, and people. Not only through identifying relevant knowledge transfer mechanisms, but also by describing them in context, this study emphasizes how such mechanisms relate to specialization and integration efforts, and how they should be orchestrated to be effective in coping with embeddedness. Specifically, each study in this dissertation highlights a couple of these mechanisms (for example boundary objects, workshops, writing reports, knowledge pollination) and illustrates how, and sometimes under what conditions, knowledge transfer mechanisms can be either conflicting or effective. Whereas some existing studies have identified transfer mechanisms (Hong & Nguyen 2009; Lahiri 2010), and others have identified how some forms of R&D knowledge are more easy to transfer than others (Andersen, 2013; Hsiao, 2006), none of these studies have described how to balance and manage these mechanisms in a real practice setting (the how part). By including objectives of specialization and integration, and linking them to embeddedness literature, I have developed a framework which provides understanding of what and how knowledge management and knowledge transfer mechanisms can be useful. This brings forth several implications.

First, although literature has identified many knowledge management mechanisms that can facilitate knowledge flows in organizations, it is still lacking insight on how such activities can
lead to the actual creation of knowledge (McIver, Lengnick-Hall, Lengnick-Hall & Ramachandran, 2013). Knowledge transfer literature takes into account that knowledge can be embedded in practice to different extents and should be assessed to see what kind of transfer mechanism can be successful (Berends, Debackere & Weggeman, 2006; Cummings & Teng 2003; Davenport and Prusak, 1998). However, most of this literature does not take into account the actual situated learning process that is entangled with the creation of embedded knowledge (see Gertler, 2003). This means that this literature takes embedded knowledge as a starting point and then elaborates on different knowledge transfer mechanisms. By taking a practice based perspective, (i.e., knowing is not separable from doing, and knowledge is created in a social process (Nicolini, Gherardi & Yanov, 2003: p.8)), I was able to illustrate cases including the development of embedded knowledge, and identified several processes that enrich the literature on knowledge transfer mechanisms. For example, Chapter 3 on boundary objects in new joint fields takes a look at what actually happens in practice when using tools for knowledge transfer, and indicates that there is more to it than solely looking at the sort of knowledge to be transferred. I relate boundary objects to their past and future context to signify their embeddedness in practice. The study denotes the creation of a new joint field as the context for collaboration, and elaborates on routines and path dependent structures of different units as important antecedents for the success, or failure, of knowledge transfer mechanisms. Chapter 4 on knowledge pollination describes how engineering consultants disembed and re-embed critical knowledge throughout different projects, hereby integrating knowledge from different locations and creating new knowledge. Knowledge pollination is a mechanism that I identified by adopting a practice perspective and projecting it onto the challenge of managing embeddedness. This process was identified by focusing on how engineering consultants work in practice (as opposed to how the organization formally designed their work). Knowledge pollination can therefore be seen as a knowledge transfer mechanism in practice.

Both studies extend prior work on knowledge transfer mechanisms (e.g., Cummings & Teng, 2003, Foss & Pedersen, 2002; Song, Berends, Van der Bij & Weggeman, 2007) by connecting the knowledge based view with a perspective on practice, which resulted in a richer understanding of dispersed knowledge development. Specifically, chapter 3 contributes to the picture of antecedents for knowledge transfer as studied by, for example, Cummings and Teng
Their study on knowledge transfer mechanism success discusses several contexts (knowledge, recipient, relational, activity) that must be taken into account when developing such mechanisms. They acknowledge the embeddedness of knowledge as a significant factor in transfer success, and also suggest aligning contextual dimensions to facilitate knowledge transfer. However, they do not discuss contextual dimensions other than potential relationship distances and the degree of interactions. The findings in this dissertation show not only the kind of knowledge that should be assessed, but also routines and specific work practices contextual to that knowledge (such as the way 3D CAD was used) that should be taken into account when developing knowledge transfer mechanisms. These findings provide a response to the call of McIver et al (2013) to take a “knowledge in practice” perspective, in order to provide more understanding of how knowledge management can be effective in specific contexts. It entails not only a focus on knowledge, but also a focus on how people can process that knowledge in practice. This is not to say that a particular kind of transfer mechanism is suited for a particular kind of knowledge per se, but that the practice in which this knowledge is (or will be) developed must be taken into account (Carlile, 2002; McIver, 2013; Orlikowski, 2002).

Second, this dissertation shows that knowledge transfer mechanisms exist in a variety of different forms, such as boundary objects and knowledge pollination, and are found to be useful for knowledge specialization and integration on different levels. The findings show that boundary objects have different levels of interpretative flexibility, and that higher levels of this flexibility are useful in dynamic environments (Barrett & Oborn, 2010; Star, 2010). In the process of knowledge pollination, this interpretative flexibility can be seen as the ability of the actor to understand, disembed and re-embed between different contexts. In theory, such flexibility increases through experience of working in different contexts. Knowledge pollination is a process consisting of subjects (actors) that have a more interpretative flexibility than boundary objects, and therefore is clearly a more expansive knowledge-sharing mechanism (Star, 2010). On the other hand, within specific practice settings such as project environments, the process of knowledge pollination can only facilitate knowledge-sharing to some extent. The effect mostly relates to relational and structural embeddedness i.e., to facilitating a social context. In specific practice settings, boundary objects such as CAD systems or wikis are better suited to directly facilitating the development of a specific technology or practice. More conceptually in line with specialization and integration
objectives, knowledge pollination can be seen as a knowledge transfer mechanism that facilitates integration on an organizational level. Boundary objects are better suited to facilitating specialization and integration on a practice level.

As discussed in the R&D management model in chapter 5, these different organizational and practice levels of integration are interrelated, which also provides implications for the interrelatedness between knowledge transfer mechanisms on different levels. Whilst boundary objects can facilitate knowledge transfer in a focused, more specific way, knowledge pollination facilitates knowledge transfer at broader organizational levels. Considering the case of Graphic in chapter 3, knowledge pollination could have been an effective knowledge transfer mechanism in the build-up to Graphic’s dispersed Mesa project. As knowledge pollination bridges different embedded contexts, it could have created more structural and relational embeddedness, which in turn builds the social and practice context needed to collaborate. Management would subsequently be aware of incompatibilities of the CAD system, and would be able to act accordingly before the project was taken to practice. Conversely, boundary objects can either hamper or facilitate the process of knowledge pollination. For example, the EnerTech case in chapter 4 describes how silos of knowledge exist between R&D departments because several boundary objects (databases, wikis) obstruct rather than facilitate knowledge availability in the organization. Going back to the concept of interpretative flexibility, if boundary objects can facilitate knowledge transfer in different contexts at the same time, it is conceivable that such objects can support knowledge pollination by supporting engineering consultants in transferring embedded knowledge.

Third, as discussed in chapter 4, knowledge transfer mechanisms can emerge from practice in dispersed settings. The concept of knowledge pollination in itself is a contribution to literature on knowledge transfer mechanisms. The phenomenon of knowledge pollination can be seen as a knowledge transfer mechanism because the concept describes how knowledge can be disembedded from its context by engineering consultants who understand how knowledge is embedded, and transferred and (somewhat) re-embedded in other contexts. This process is not found as an explicit task, but as something that is done through doing their work, i.e., interacting with practice (Blackler 1995; Brown & Duguid 1991; 2001; Cook & Brown 1999; Gherardi 2000; Orlikowski 2002; Wenger 2000). It contributes to and extends literature on the importance of intra-
organizational linkages in dispersed settings (Guler & Nerkar, 2012; Lahiri, 2010; Singh, 2008) by showing how powerful such linkages are in practice, and how such linkages can evolve *through* practice. Besides taking a clear-cut view on knowledge-sharing mechanisms that exist in the literature, knowledge pollination is an example of how such mechanisms can be identified by adopting a practice-based view on managing knowledge (Brown and Duguid, 1991; Lave and Wenger, 1991).

Also, related to this contribution, knowledge pollination is an example of describing a network perspective involving formal learning, informal learning, and transactive memory. Much literature has addressed networks in dispersed R&D settings with a focus on, for example, organizational configuration (Gassman & Von Zedtwitz, 1999; Lam, 2003; Medcof, 2001), social networks for knowledge retrieval (Cross, Borgatti & Parker, 2002; Katz & Allen, 2004), or knowledge in networks (Birkinshaw, 2002; Foss & Pedersen, 2002; Tsai, 2001), but none have focused specifically on how such informal developed networks can be seen as mechanisms to overcome the embeddedness of knowledge in dispersed R&D. By describing the process of knowledge pollination, I demonstrated how such emerging networks can play a crucial role as knowledge transfer mechanisms, although not deliberately managed as such.

### 6.3. Practical implications

As this dissertation builds on empirical studies on how management deals with knowledge in dispersed R&D settings, it brings forth useful recommendations for management. Taken together, the studies have overall practical implications, as discussed in this section.

#### 6.3.1. Awareness of different settings

The first implication for management that emerges from the findings is to not only understand, but also to echo in the organization, the awareness that different local units with different histories and approaches to work are involved within dispersed collaborative settings. While this may sound obvious, according to the managers interviewed for this dissertation it remains one of the key
management concerns in dispersed collaborations. The findings provide at least two main reasons for this.

First, the lack of a shared social and practice context means that a higher level of formalization is necessary to account for coordination (such as progress reports or allocating responsibilities). In one central setting much coordination may occur automatically, but this does not often occur as a matter of course in dispersed settings. The downside to having a higher level of formalization is that it can interfere with the knowledge-creation process itself, negatively affecting a shared practice context. A clear example of such a missing context is addressed in chapter 3 on boundary objects. Although two groups were willing to collaborate on a new piece of technology, they were not able to develop together because they were not able to share their practices to a sufficient degree. Chapter 5 highlights the importance of establishing sufficient structure and relationships in order to create adequate context for the actual collaborative work. Chapter 2 provides key factors that should be taken into account when creating such a context.

Second, it is important to consider the question of whether the development of new technologies can be organized in a dispersed way at all. Besides the awareness of differences between units and the facilitation of a shared context, the findings indicate that before collaboration should take place, management can benefit from assessing the ability to create a shared-practice context, i.e., how is the collaboration structured? Is there a shared context on which to build further collaboration? Can tools be aligned? Can knowledge be decoupled and shared through ICTs, or should people be mobilized? Knowledge that is relatively easy to decouple has a better opportunity to be shared in dispersed settings, for instance because technologies can be taken apart and developed further somewhat separately, or because people are easily transferred between locations. Assessing the situation prior to and during collaborations can help decision-making on types of collaboration, and in later stages on adequate management support.

6.3.2. Organizing for knowledge

This dissertation elucidates some of the substantial differences between managing knowledge in centrally organized R&D and in geographically dispersed settings. The awareness of managing this
setting as a learning process itself might seem obvious, but it may not be obvious to management that has performed management tasks in central R&D over the long term. Some fundamental differences exist, some processes do not occur automatically, and some aspects require more attention than in traditional settings. In dispersed settings, linkages between locations are not as spontaneously formed or maintained, and the managerial activity of organizing for knowledge seems all the more needful. I have identified several knowledge management insights for coping with challenges specific to R&D in dispersed settings (Table 6.2). Some of these insights are also evident in centrally organized R&D, or come in useful in other organizational departments, i.e., they can be quite familiar knowledge management strategies. But most of these mechanisms are proven powerful specifically in dispersed practice settings. For many of the insights identified, management reveals that these are coping mechanisms that have evolved over time and through a process of trial and error. Some are an outcome of learning processes of management, some are still “under construction.” It is recommended that management evaluate the types of knowledge management challenges these mechanisms are used for in their own specific settings, as well as how such mechanisms can fit within particular settings. Table 6.2 provides a useful guide to such evaluation.

Furthermore, this dissertation identified the process of knowledge pollination as a mechanism for integrating critical knowledge throughout different R&D units by having internal engineering consultants mobile between different locations. The process identified had not been set up by managerial intervention, but rather emerged from the practices of the engineering consultants themselves. In addition, the organization under study was not openly aware of this knowledge-integration process. This view unquestionably has implications for management as it would be interesting to see whether this process exists in other organizations, as well as how it can be stimulated without interfering too much with the practices of such traveling agents. More importantly, these findings indicate that more attention is needed for emergent knowledge transfer mechanisms in order to gain a better understanding of people in organizations as carriers and creators of knowledge, even – and particularly – in dispersed settings.
6.3.3. Combining bottom-up and top-down approaches to managing knowledge

A third implication for management which emerges from the main findings is the dual role management can have in managing dispersed R&D settings. As introduced in chapter 2, and elaborated on in chapter 5, managing dispersed R&D has both deliberate and emergent aspects. Determining the organization’s road map is a deliberate management process, while the facilitating of an interface for locations, in order to ensure that a social and practice context is facilitated, requires a more peripheral and hands-off approach. In dispersed settings, the natural tendency for managers involved in such collaborations (e.g., project managers or local managers) is to emphasize deliberate interventions in order to compensate for the complications that result from dispersing R&D – such as compensating for a missing practice context, informal networks, etc. Although more formalization can create clear work agreements, it also increases the distance between managerial layers and different locations (as in centrally organized settings, much is taken care of by informal management, routines, or the greater opportunity for (in)formal interaction between people). Managers facing dispersed settings should be aware of the self-organizing processes that occur in centrally organized settings, and whether and how these processes can be managed either through deliberate coping mechanisms or through more emergent knowledge transfer mechanisms.

6.4. Limitations of the research

There are several limitations to the research presented in this dissertation that should be considered. A common so-called limitation in qualitative research is that the findings from case study research are difficult to generalize in the same way deductive quantitative research is supposed to do. The studies in this dissertation are conducted in complex and therefore unique organizational contexts and whether or not learning derived from the findings is directly applicable in other contexts can be questionable. However, considering the multifaceted organization of R&D work, the complexity of its context, and the still fairly unexplored field of interest I entered at the beginning of this dissertation’s research (answering a how question in this context), it seems justified to study the empirical context in-depth (Bamberger & Pratt, 2010; Cook & Brown, 1999; Golden-Biddle & Locke, 2007; Van de Ven & Johnson, 2006). By adopting an inductive
qualitative research approach, I was able to provide a so-called “thick description” (Geertz, 1994) which shaped the description, interpretation, and explanation of different processes and their relationships in dispersed R&D settings. Such detailed descriptions provide many new insights for theory and research to elaborate on, and should be seen as explorations for new theory (Walsham, 1995). An example is the concept of knowledge pollination emerging from the data. By identifying this concept and its underlying processes I have shed light on an organizational phenomena that was not yet elaborated on. This form of in-depth investigation is time-consuming, but it delivers in-depth insights to the phenomena. Although generalization as done with deductive quantitative research is impossible, and might also be less useful in this regard, the studies do generalize from their empirical findings by adding contribution to existing theoretical concepts, and by identifying and introducing new concepts to the (academic) field (See also Lee & Baskerville, 2003).

A second limitation can be found in the practice based approach I have adopted in several studies. I have made several statements on how to consider knowledge in practice, such as knowledge is knowing and doing (Nicolini et al, 2003), knowledge is intrinsically bound to practice (Orlikowski, 2007), and knowledge is always a combination of know-what, know-how, know-why and know-who (Lundvall & Johnson, 1994). However, the research approach of primarily taking interviews is a retrospective way of gaining understanding of practice. I base most of my findings on knowledge from key persons, which is made explicit in transcribed interviews, and taken outside of the context in which it made sense. This approach does not fully respect the fundamentals of practice based research, and may have impacted my findings. Although I have continuously iterated between the research context, relevant theory, and the informed interpretations of myself and my research team in order to create a comprehensive understanding of practice, I am aware that a research approach that reflects a better practice based approach, such as ethnographies, can be aimed for.

Third, because I have conducted all my case studies over a limited period of time, I was unable to draw longitudinal conclusions from my findings. Specifically, I have described processes, such as managing the tension between specialization and integration (chapter 5), without actually examining how managers develop capabilities for understanding and coping with such dynamic processes over time. The data I have acquired during this research is mainly
retrospective, and does not involve data sequences records from one particular interviewee or case. Longitudinal data can track interactions between different processes and how these evolve over time. Interpreting the second part of my overall research question, namely how managers deal with challenges in practice, could result in the expectation to use longitudinal data to answer this question. The concepts of learning and developing capabilities did indeed emerge in many of the interviews. Interviewees have touched upon these concepts by discussing the idea that organizing knowledge within the dispersed R&D setting is something that evolves over time, not only for managers as actors, but also for organizations as a whole. However, since these concepts came to the surface later in the analysis I did not cover the concepts thoroughly in each study, since I could not develop sufficient grounding in the data to draw new insights or build theory on.

6.5. Future research directions

The findings of this dissertation provide many interesting insights for theory and practice, and also hint at new avenues for future research. With regard to some of the limitations discussed in the previous paragraph, one suggestion is to elaborate on the emerging concepts in this dissertation in order to further unravel and strengthen their fundamentals. This could be done not only by replicating the studies in different R&D settings, but also by conducting longitudinal research in the same settings. Concepts such as new joint fields in dispersed R&D (Chapter 3), knowledge pollination (Chapter 4), or the management model proposed in Chapter 5 can be improved to create more predictive power (Tsang & Kwan, 1999). In addition to concepts that have been identified in the separate studies, there are several overall findings that will be interesting to address in future research. These will be discussed here.

First, the concept of embeddedness needs more research in order to develop a richer understanding of what embeddedness in the specific setting of R&D entails. As discussed in paragraph 6.2.2., a higher degree of embeddedness is favorable for specialization, but from an integration perspective it would be preferable to have a lower degree of embeddedness (Andersen, 2013). Especially evident in dispersed settings, where the actual dispersion of R&D increases embeddedness, the concept is central to integration efforts. This dissertation sheds light on the tension between specialization and integration objectives and embeddedness, but it does not unravel the concept of embeddedness further. These insights ask for further examination. Future
research could provide more understanding of, for example, other issues which are subject to embeddedness and which bear investigation in the light of dispersed R&D. In this dissertation, I have made the assumption that it is knowledge that is embedded in people, tools, practices and contexts. But I also provide examples of tools that are embedded in practices (chapter 3), or practices that are embedded in contexts and people (chapter 4). It could be interesting to take another point of departure than the view of managing knowledge, and to look at, for example, how practices create embeddedness and are embedded in contexts. Some study has been carried out on, for example, how embeddedness affects work practices (e.g., Hsiao et al, 2006), how tacit knowledge relates to embeddedness (e.g., Gertler, 2003), or what embedded contexts can be (e.g., Lervik, 2008). More research with a primary focus on embeddedness would help unravel the concept and provide better overview on what embeddedness entails, how embeddedness develops in practice, and how it relates to the development of new knowledge in organizations (e.g., Fahy, Easterby-Smith & Lervik, 2013). This, in turn, provides better understanding of how to manage specialization and integration efforts at the same time.

Second, throughout the research I have deliberately ignored the involvement of third parties in R&D because the research primarily focused on intra-organizational collaborations and processes. Involving external parties within this particular research would make theorizing more complex and would not necessarily contribute to the implications that are now drawn. However, R&D work often entails additional integration efforts with third parties (Enkel, Gassmann & Chesbrough, 2009; Grimpe & Kaiser, 2010). Recent trends in the organizational design of R&D point towards stretching the innovation process of organizations further than traditional boundaries, towards forms of open innovation and meta-organizations (Ahrne & Brunsson, 2005; Gulati, Puranam & Tushman, 2012). Despite transaction costs (search, contract, and control costs) that derive from collaboration with external partners, an increasing number of organizations enter into collaborative relationships with other R&D organizations. In this light it could be interesting to theorize and research how the implications of this study hold in such contexts. Considering the challenge of managing specialization and integration, several components of the R&D process change. Specialization can be found outside of organizational boundaries, and the primary role for organizations then is to steer integration efforts between separate entities (Grant, 1996). This suggests that in such settings separate entities do not specialize together to the same degree as in
intra-organizational settings, but merely provide specialized technologies that meet pre-defined requirements and only collaborate in practice for alignment between technologies. From the point of view of technology development, this organizational design makes sense if one considers technology development to be a process of evolvement, recombination, morphing, and creating offspring (Arthur, 2009). It could be interesting to further investigate how specialization and integration pressures are dealt with in settings in which the innovation process is not necessarily performed in-house. Will a tension also exist between the two processes in such settings, and if so, what is the relationship between the two processes, and can research on either type of organizational design provide implications for one another? Answering these questions can have important implications for theory not only on R&D work and technology management (e.g., Allen, 1984; Enkel et al, 2009; Pavitt, 1990), but also on more general organization theories such as organization design (e.g., Gulati et al, 2012; Gupta, Smith & Shalley, 2006), contingency theory (e.g., Ambos & Schlegelmilch, 2007; Hitt et al, 2001), or transaction cost economics (e.g., Peteraf, 1993; Williamson, 2005).

6.6. Concluding remarks
The example of the conversation that preceded the introduction to this dissertation, a discussion between an R&D lead manager and me about the car paint of a miniature car, presents key subjects addressed by this dissertation. It addresses how R&D units in local contexts specialize in car coating for that specific area. It also addresses the point that the organization tends to learn from this specialized knowledge, by creating collaborations between units. It addresses that knowledge can be embedded in such contexts, and in technology, in this case car coating. It is not so much the output of the paint itself that is difficult to extract from its context, but the process to determine what will be the best paint: it consists of experience in the field, know-how, technical knowledge, procedures, the local context, and so on. The studies reported on in this dissertation give insight into the challenges organizations face when managing dispersed R&D settings, and elaborate on how such challenges can be coped with. Collaboration efforts within R&D organizations are subject to both specialization and integration objectives, which in turn are complicated because of dispersed settings. The concept of the embeddedness of knowledge expresses the tension between...
specialization and integration efforts even more, and provides useful insights on how R&D work can be managed optimally for the organization as a whole. The R&D lead manager in this example also explained me that performing in dispersed contexts is, from the start, a matter of setting aside what works in the context you are used to, and understanding and becoming receptive to how things are done in other contexts – and more importantly, why things are done. Connecting this, while keeping a close eye on other organizational objectives, is key. With this dissertation I provide a more holistic perspective to managing dispersed R&D, by unpacking empirical and theoretical interrelations between perspectives on knowledge, challenges, R&D objectives, and coping processes for management.
### APPENDIX A: Interview protocol Chapter 2

| 1 | **Can you describe your position and work activities?**  
*Can you describe the history of your career in short?*  
*How long have you worked for this organization?*  
*How long have you had this position?*  
*What responsibilities does your position entail? /What does an ordinary day look like?*** |
| 2 | **How is R&D organized at … in general?**  
*How is the organization structured?*  
*How is R&D located?*  
*Why is R&D located there?*  
*Is R&D captive or outsourced? (distribution intern/extern)*  
*Does the organization collaborate with other organizations on R&D?*** |
| 3 | **How is R&D organized at your specific division?**  
*What technologies and products is your R&D division involved in?*  
*What is the background of employees working in this division?*  
*Is R&D in this division held captive or is it outsourced?*  
*Does this division collaborate with other divisions or organizations?*  
*How is performance of R&D measured in this division?*** |
| 4 | **Can you explain how onshore and offshore units collaborate?**  
*Are there formal agreements on how to work together between onshore and offshore units?*  
*Who (or what) carries responsibility for the well-being of this collaboration?*  
*How does this collaboration work out in practice? In other words, do you see differences between formal agreements and practice?*  
*What differences do you experience between onshore and offshore units?*** |
| 5 | **How does knowledge sharing/transfer take place between onshore and offshore R&D units?(process/practice)**  
*How do onshore and offshore units communicate with each other?*  
*What tools/systems are used to communicate with each other?*  
*How important is personal contact in knowledge sharing and transfer?*  
*How frequent do onshore and offshore employees share knowledge?*  
*What persons/functions have to share/transfer knowledge with each other?*  
*Can you explain if and how agreements on this knowledge sharing/transfer are established?*  
*Do onshore and offshore units exchange employees?*** |
| 6 | **What are properties of the kinds of knowledge that is transferred or shared between onshore and offshore R&D units?**  
*Can you give examples of the kind of knowledge shared between R&D onshore and offshore units?*  
*Can you describe the level of embeddedness of knowledge and expertise in people, systems and routines?*  
*Can you elaborate some more on the complexity of the knowledge shared?*** |
| 7 | **What factors influence knowledge transfer between onshore and offshore R&D units?**  
*Can you name similarities and differences between the knowledge base of employees of onshore and offshore units?*  
*To what extent does the onshore unit understands knowledge of the offshore unit?*  
*What factors influence this extent?*  
*To what extent does the offshore unit understands knowledge of the onshore unit?*  
*What factors influence this extent?*** |
<p>| 8 | <strong>How do these factors influence the process of knowledge sharing?</strong>* |</p>
<table>
<thead>
<tr>
<th>Level</th>
<th>Concepts</th>
<th>Categories (2\textsuperscript{nd} order coding)</th>
<th>Codes from quotes in the interviews (1\textsuperscript{st} order coding, open and axial)</th>
</tr>
</thead>
</table>
| Unit level         | Dominant logics               | Ways of working                               | Change ways of working  
|                    |                               |                                               | Hire-fire  
|                    |                               |                                               | Overcoming problems in different ways of working  
|                    |                               |                                               | Synchronizing, monitoring  
|                    |                               | Awareness                                     | Experience  
|                    |                               |                                               | Training  
|                    |                               |                                               | Differences  
| Cultural awareness | Culture                       |                                               | Hierarchy  
|                    |                               |                                               | Working in practice  
|                    |                               |                                               | Staff  
|                    |                               |                                               | Ways of working  
|                    |                               |                                               | Formal agreements on communication structure  
|                    |                               |                                               | Communication systems  
| Knowledge level    | Common knowledge              | Similarity between knowledge base             | Technical  
|                    |                               | Differences between knowledge base            | Education  
|                    |                               |                                               | Experience  
| Knowledge embeddedness | Local knowledge             |                                               | Project  
|                    |                               |                                               | People  
|                    |                               |                                               | How to find knowledge  
|                    | Knowledge form                |                                               | Experience  
|                    |                               |                                               | Know-how  
|                    |                               |                                               | Explicit  
|                    | Managing embeddedness         |                                               | Visits  
|                    |                               |                                               | Shared knowledge base  
| Relationship level | Structural embeddedness       | Cohesion                                      | Synchronizing, monitoring  
|                    | R&D structure                 |                                               | Relation R&D-marketing-sales  
|                    |                               |                                               | Boundaries to knowledge internal  
|                    |                               |                                               | Boundaries to research external  
|                    |                               |                                               | Boundaries to research internal  

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<table>
<thead>
<tr>
<th>Integration of systems</th>
<th>Communication with other units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>Relational embeddedness</td>
</tr>
<tr>
<td>Projects between units</td>
<td>Trust</td>
</tr>
<tr>
<td>Managing us vs. them</td>
<td>Identity</td>
</tr>
<tr>
<td>Openness</td>
<td>Face to face contact</td>
</tr>
<tr>
<td>Direct links</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Managing us vs. Them</td>
</tr>
<tr>
<td></td>
<td>Visiting other units</td>
</tr>
<tr>
<td></td>
<td>Communication systems</td>
</tr>
<tr>
<td></td>
<td>Language</td>
</tr>
</tbody>
</table>

**Single codes frequently occurring**

- Advantage offshoring
- Building up R&D unit
- Initiation of projects
- Issues
- Opportunity spotting
- Reason for offshoring
- What units do what
## APPENDIX C: Coding scheme Chapter 3

<table>
<thead>
<tr>
<th>Level</th>
<th>Concepts</th>
<th>Categories (2nd order coding)</th>
<th>Codes from quotes in the interviews (1st order coding, open and axial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project mesa</td>
<td>Boundary objects</td>
<td>Wiki</td>
<td>Collaboration software&lt;br&gt;Ways to communicate&lt;br&gt;Cad&lt;br&gt;Incompatibility&lt;br&gt;Knowledge embeddedness&lt;br&gt;Ways to communicate&lt;br&gt;Interpretative flexibility&lt;br&gt;Incompatibility&lt;br&gt;Open software&lt;br&gt;Routines</td>
</tr>
<tr>
<td>New joint field</td>
<td>Project environment</td>
<td>People&lt;br&gt;Tasks&lt;br&gt;Systems&lt;br&gt; Routines</td>
<td>Different technologies&lt;br&gt;Different management&lt;br&gt;Difficulties in collaboration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lessons learned&lt;br&gt;Management&lt;br&gt;Tools&lt;br&gt;Awareness of other units</td>
</tr>
<tr>
<td>Unit NL</td>
<td>R&amp;D philosophy</td>
<td>Hierarchy&lt;br&gt;Product&lt;br&gt;Ways of working</td>
<td>Technology ownership&lt;br&gt;Efficiency&lt;br&gt;Welding technology&lt;br&gt;Headquarters</td>
</tr>
<tr>
<td></td>
<td>Technology ownership</td>
<td></td>
<td>Employees&lt;br&gt;No. Of years employed&lt;br&gt; Function&lt;br&gt;History</td>
</tr>
<tr>
<td>Unit CA</td>
<td>R&amp;D philosophy</td>
<td>Hierarchy&lt;br&gt;Product&lt;br&gt;Ways of working</td>
<td>Technology ownership&lt;br&gt;Experimental designs&lt;br&gt;Screeving technologies&lt;br&gt;Independent R&amp;D</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Relationship</th>
<th>Differences CA-NL</th>
<th>Formal-informal</th>
<th>Ways of working</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees No. Of years employed</td>
<td>Function History Culture</td>
<td>Kind of knowledge involved</td>
<td>Experience Difficult to identify knowledge Cad Wiki Secured intranet (not accessible)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cross-pollination</td>
<td>Visits overseas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frustrations</td>
<td>Differences Project ownership Different ways of working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology ownership</td>
<td>Leading collaboration Differences in technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reason for collaboration</td>
<td>Experience in ca Resources</td>
</tr>
<tr>
<td>Single codes frequently occurring</td>
<td>Developing projects in general Efficiency/innovation issues Employment Knowledge retention Singapore Function Years of employment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX D: Interview protocol Chapter 4

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Can you tell what is your position within the company and about the work that you do?</td>
</tr>
<tr>
<td>2</td>
<td>How do you work in a team/project? How do you work geographically dispersed?</td>
</tr>
<tr>
<td>3</td>
<td>How do you learn within your job?</td>
</tr>
<tr>
<td>4</td>
<td>How do you learn from previous projects/jobs?</td>
</tr>
<tr>
<td>5</td>
<td>How do you use your network in the organization to learn or acquire adequate knowledge?</td>
</tr>
<tr>
<td>6</td>
<td>How do you communicate on work related issues? How does management support this/is this facilitated?</td>
</tr>
<tr>
<td>7</td>
<td>Do you encounter difficulties in the communication in the team (distance). Why? Can you give examples?</td>
</tr>
<tr>
<td>8</td>
<td>Besides communication, can you say something about a different understanding on project goals? Do team members or management have different interpretations of the meaning of things? Different perception of a solution or a problem? How do you encounter this?</td>
</tr>
<tr>
<td>9</td>
<td>I assume members of your team have different practices. Can you explain how the team comes to a shared goal or shared understanding? Or not? What does management do to create this?</td>
</tr>
<tr>
<td>10</td>
<td>Then, if all is set,(specialization) how do you work together on a project? Is there flexibility to change the rules if necessary for the work?</td>
</tr>
<tr>
<td>11</td>
<td>How do you make your specialization/the project visible to management or other parts of the organization? How is this managed? Is this managed beforehand by management?</td>
</tr>
<tr>
<td>12</td>
<td>From what we talked about, is there anything left to discuss that you believe is important for understanding how you work in dispersed settings?</td>
</tr>
</tbody>
</table>
## APPENDIX E: Coding scheme Chapter 4

<table>
<thead>
<tr>
<th>Level</th>
<th>Concepts</th>
<th>Categories (2\textsuperscript{nd} order coding)</th>
<th>Codes from quotes in the interviews (1\textsuperscript{st} order coding, open and axial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge pollination organizational learning</td>
<td>Knowledge embeddedness</td>
<td>Situated nature</td>
<td>Understanding context of problem Not retrievable through reports only Need to be within practice Unstandardized solutions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Working dispersed</td>
<td>Working in silos Confidentiality issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integral nature</td>
<td>Breaking barriers Process of heedful interrelation Experience with similar problems Importance of network development through practice</td>
</tr>
<tr>
<td>Transactive memory</td>
<td>Seeking/asking advice</td>
<td>Seeking expertise from other ECs</td>
<td>Consulting other ECs Asking focal points for reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building relationships</td>
<td>Building relationships with other ECs Building relationships within projects Building relationships within locations</td>
</tr>
<tr>
<td>Learning in practice</td>
<td>Negotiation</td>
<td>Discussion with colleagues on technology</td>
<td>Coffeepot method</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heedful interrelating</td>
<td>Interrelating between experience and context Decision making Creating project overview Problem solving</td>
</tr>
<tr>
<td>Organized learning</td>
<td>Formal knowledge sharing sessions</td>
<td>Job handover</td>
<td>Lunch and learn sessions Ask the expert sessions Practices worth replicating Workshops on lessons learned Introduction courses at sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facilitate environment</td>
<td>Face to face Transactive memory Global work Visiting other units</td>
</tr>
</tbody>
</table>
| Documentation | Writing down general project guidelines  
Technology reports  
Writing process reports |
| --- | --- |
| Boundaries to organized learning | Working in silos  
Protecting knowledge |
| Knowledge embeddedness | Situated nature  
Understanding context of problem  
Not retrievable through reports only  
Need to be within practice  
Unstandardized solutions |
| Integral nature | Process of heedful interrelation  
Experience with similar problems  
Importance of network development through practice  
Not retrievable in system |
| Knowledge retrieval | Problems  
Protecting knowledge  
Silos  
Outdated  
Not applicable knowledge  
Knowledge leaves organization  
Resides in practice  
Learning from project |
| Procedural knowledge | Transactive memory  
Know-how  
Experience  
Memory  
Pollination |
| Transactive memory | Seeking advice  
Building relationships  
Experience |
| Single codes frequently occurring | What is an expert?  
Years in the organization  
Personalization  
Codification  
Bringing the right people together |
### APPENDIX F: Coding scheme Chapter 5

<table>
<thead>
<tr>
<th>Level</th>
<th>Concepts</th>
<th>Categories (2nd order coding)</th>
<th>Codes from quotes in the interviews (1st order coding, open and axial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connections level</td>
<td>Organizational structure</td>
<td>Formal agreement on interface</td>
<td>Hierarchy (managers) Reporting Knowledge boundaries in projects Bringing the right people together Task allocation in projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Network Relation R&amp;D, marketing &amp; sales Dispersed teams</td>
</tr>
<tr>
<td>Establishing connections</td>
<td>Facilitating a context for</td>
<td>Communication system Problems related to IT infrastructure</td>
<td>Formal/informal connections Change ways of working Breaking barriers Overcoming confidentiality issues</td>
</tr>
<tr>
<td></td>
<td>Collaboration</td>
<td>Collaboration structure Communication between locations Communication within unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overcoming problems associated</td>
<td>Formal/informal connections Change ways of working Breaking barriers Overcoming confidentiality issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with different ways of working</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Specific management</td>
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<td>Willingness to collaborate Problems/frustrations between settings</td>
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<td>Allowing for specialization</td>
<td>Situated learning</td>
<td>Creating knowledge in practice Cross referencing (combining knowledge to learn from each other, using each other's solutions)</td>
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<td>Collaboration among engineers</td>
<td>Knowledge sharing mechanisms</td>
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REFERENCES


HET MANAGEN VAN KENNIS IN ORGANISATIES MET VERSPREIDE R&D

Een kwalitatieve studie naar uitdagingen voor management en inzichten vanuit de praktijk

Deze Nederlandse vertaling is een samenvatting van het proefschrift getiteld: 'Managing knowledge in dispersed R&D settings: a qualitative study of management challenges and insights from practice'.

R&D organisaties zoeken tegenwoordig internationaal naar waardevolle kennis voor technologische ontwikkeling. Organisaties vestigen zich in andere landen om bijvoorbeeld dicht bij een afzetmarkt te zijn, dicht bij leveranciers, grondstoffen, of om geschikt personeel te kunnen werven. Naast dat een organisatie profiteert van de voordelen van verspreide R&D, vergt zo een verspreiding een andere investering in de coördinatie en integratie van kennis door de organisatie heen. Veel internationale R&D projecten worden voortijdig stopgezet omdat organisaties er niet in slagen om voldoende resultaat te behalen. De studies in dit proefschrift gaan over uitdagingen die specifiek zijn voor het managen van kennis in verspreide R&D.

Verspreide R&D

Specifiek aan het internationaal verspreiden van het R&D onderdeel van een organisatie is dat de R&D over het algemeen de 'kern' van ontwikkeling en innovatie is, en in tegenstellingen tot andere bedrijfsonderdelen vaak centraal georganiseerd bleef. De laatste jaren wordt R&D meer internationaal georganiseerd, met als grootste voordelen het zich dichter bij lokale markten huisvesten, en toegang verkrijgen tot de juiste gespecialiseerde mensen.
Er verandert veel als R&D verspreid wordt georganiseerd. Terwijl in centraal georganiseerde R&D face-to-face communicatie normaal is (zowel formeel als informeel), is hier in verspreide R&D veel minder gelegenheid voor. Mensen van verschillende locaties kennen elkaar en elkaars expertise minder goed, en werken minder vaak met elkaar samen. Organisaties proberen hun ICT hier op in te richten, maar dit wordt bemoeilijkt door bijvoorbeeld complexe kennis die in R&D projecten wordt toegepast en gecreëerd, verschillen per locatie, wetten omtrent het verplaatsen van kennis over landsgrenzen, en het beschermen van kennis binnen de organisatie.

Hiernaast specialiseren verspreide R&D locaties zich gerichter doordat er per locatie andere kennis aanwezig is, en dit per locatie meer afgesplitst wordt ontwikkeld. Dit heeft als voordeel dat er op verschillende locaties unieke kennis kan worden geworven, maar brengt ook de nodige uitdagingen met zich mee. Waardervolle kennis zoals know-how, expertise, en individuele ervaring is moeilijk expliciet te maken. Dit soort kennis is veelal ingebed in de context waarin het is gevormd, zoals in specifieke projecten, mensen, technologieën, en locaties, en daardoor niet zomaar op te slaan en over te dragen naar andere delen van de organisatie. Binnen centraal georganiseerde R&D wordt zulke kennis makkelijker gedeeld, veelal informeel en tijdens het werk zelf, doordat mensen fysiek met elkaar werken of elkaar (of elkaars expertise) kennen.

Terwijl organisaties proberen om specialistische kennis in verschillende locaties te ontwikkelen, hebben zij ook het doel om deze kennis meer algemeen en breder beschikbaar te maken voor de organisatie. Omdat dergelijke waardevolle kennis moeilijk expliciet te maken is (en daarom is het vaak ook uniek en waardevol voor de organisatie), liggen hier belangrijke uitdagingen voor lokale R&D managers en hoger management.

Gedurende het onderzoek houd ik een 'practice-based' perspectief aan. Dit perspectief gaat er van uit dat kennis onlosmakelijk verbonden is met de praktijk van R&D werk en de sociale context van mensen ('kennis is doen'). In tegenstelling tot vele studies die zich alleen richten op de output vanuit specialisatie of integratieprocessen (zoals het aantal gegenereerde patenten), leg ik de nadruk op hoe kennis specialisatie- en integratieprocessen in elkaar steken en zich verhouden in de praktijk. De algemene onderzoeksvraag die hier bij aansluit luidt:
Wat zijn kennis-gerelateerde uitdagingen voor geografisch verspreide R&D, en hoe gaan
organisaties met deze uitdagingen in de praktijk om?

**Kennis in R&D werk**

Om beter uit te kunnen leggen waarom R&D kennis complexe kennis is, behelst het concept
kennis in dit proefschrift een brede definitie. Kennis kan bijvoorbeeld onbewust, expliciet,
impliciet, lokaal of algemeen zijn, maar het kan ook bestaan uit kennis over hoe iets gedaan kan
worden (know-how), wie expertise bezit (know-who), of waarom iets op een bepaalde manier
gedaan moet worden (know-why). Kennis kan door verschillende mensen op verschillende
manieren begrepen worden. Theorie over kennis in organisaties beschrijft dat kennis meestal een
combinatie is van expliciete en impliciete kennis. Kennis kan voor een deel expliciet gemaakt
worden, maar de ontvanger van zulke kennis zal bepaalde voorkennis moeten bezitten om het te
begrijpen. Zo zal een technisch rapport niet worden begrepen door iemand zonder die technische
achtergrond. Een lezer zal iets van technische basiskennis moeten hebben, keuzes in technisch
ontwerp begrijpen, en bekend moeten zijn met de context (locatie, project) waarin het rapport is
geschreven.

Ook wordt er duidelijk verschil gemaakt tussen lokale en algemene kennis. Lokale (of
plaatselijke) kennis is specifiek voor een context en bestaat meestal impliciet in mensen, hun
werk, en routines. Deze kennis is moeilijk expliciet te maken en te verplaatsen, en kan daarom
uniek en waardevol voor de organisatie zijn. Algemene kennis is kennis wat meer universeel
gemaakt is voor andere delen van de organisatie, deels door kennis expliciet te maken, deels door
kennis te delen in vergaderingen en trainingen.

Kennis heeft drie bijkomende kenmerken in de context van R&D werk: het is integraal,
context-gebonden, en is emergent. Het integrale kenmerk houdt in dat R&D werk bestaat uit de
integratie van verschillende R&D activiteiten en specialisaties. De combinatie van verschillende
soorten kennis zorgt voor een probleemoplossingsgerichtheid en biedt de basis voor innovatieve
ideeën. Hierin is een combinatie van know-how, know-who, en know-what essentieel, en theorie
geeft aan dat dergelijk integraal werk dan ook face-to-face en actief in samenwerking kan
plaatsvinden. Het context-gebonden kenmerk houdt in dat R&D werk verbonden is aan een praktische en sociale context. Kennis wordt gecreëerd, gedeeld, en toegepast binnen een bepaalde context. Om deze kennis volledig te kunnen begrijpen en er iets mee te kunnen, zal men ook daadwerkelijk deze context moeten kennen. Het emergente kenmerk van R&D werk houdt in dat het R&D proces een bepaalde flexibiliteit nodig heeft om nieuwe kennis te creëren. Typerend aan R&D is dat er niet van te voren vaststaat hoe een innovatie (technologie/product) er uiteindelijk uit komt te zien. Gaandeweg worden er designkeuzes gemaakt om een optimale ontwikkeling te bereiken. Hiervoor is een bepaalde emergente manier van werken noodzakelijk.

**Kennispecialisatie en integratie**

Kennispecialisatie en kennisintegratie zijn twee gerelateerde doelstellingen voor verspreide R&D. De eerste doelstelling houdt in dat een organisatie tracht om lokale kenniscentra te realiseren waarin specialisatie op een specifiek kennisdomein kan plaatsvinden. Dit kan gerelateerd zijn aan de lokale industrie, de lokale afzetmarkt, of lokaal talent. Zo een R&D unit ontwikkelt eigen 'best practices', een specifieke manier van werken, eigen routines, taal, cultuur, etc., ontwikkeld hierdoor specifieke logica om lokale kennis te begrijpen en om kennis te combineren met de praktijk van het werk, waardoor nieuwe kennis wordt gecreëerd. De tweede doelstelling, die van kennisintegratie, houdt in dat een organisatie probeert organisatie-brede kennis te creëren door kennis vanuit lokale kenniscentra meer algemeen te integreren in de organisatie. Kennisintegratie kan zich op verschillende niveaus in de organisatie afspelen, bijvoorbeeld tussen verschillende R&D units, binnen projecten, maar ook tussen lokale en centrale R&D, of in combinatie met andere bedrijfsonderdelen. Ook kan integratie op verschillende manieren plaatsvinden, bijvoorbeeld in de praktijk tijdens R&D werk zelf, door het schrijven van rapporten of vergaderingen, of meer informeel bij de koffieautomaat of de waterkoeler. De definitie die ik in dit proefschrift hanteer is breed: Kennisintegratie is een voortdurend collectief proces bestaande uit het vormen, articuleren, en opnieuw definiëren van de gedeelde opvattingen door middel van sociale interactie van mensen in de organisatie.
Twee perspectieven op kennis

De 'knowledge-based view' (KBV) beschouwt kennis als het belangrijkste strategische middel van een organisatie, omdat kennis binnen organisaties sociaal complex en moeilijk te imiteren is en daardoor wordt gezien als drijfveer om competitief voordeel te behalen. Volgens de KBV wordt nieuwe kennis gecreëerd door specialisatie, en bestaat een organisatie uit verschillende stukjes heterogene kennis. Het hoofddoel van een organisatie is het integreren van deze stukjes heterogene kennis. Het 'practice-based' perspectief laat overeenkomsten zien, maar heeft een ander uitgangspunt. Dit perspectief richt zich meer op R&D werk zelf, hoe specialisatie kan plaatsvinden, en hoe kennis ingebed is in een context van praktijk, mensen, routines, en technologie. Vanuit een practice-based perspectief is het moeilijk te begrijpen dat kennis uit een context kan worden gehaald en daarbij zijn waarde behoudt.

In dit proefschrift ga ik uit van de KBV om doelstellingen van management voor specialisatie en integratie aan te geven. Ik ga ook uit van een practice-based perspectief om aandacht te geven het soort kennis wat komt kijken bij R&D werk en aan processen en condities voor het ontwikkelen van nieuwe kennis in de praktijk. Ik zie beide perspectieven als een dualiteit, omdat beiden heel duidelijk in de praktijk terug te vinden zijn en invloed op elkaar hebben. Door een practice-based perspectief te hanteren kan ik belangrijke uitdagingen voor management in de praktijk identificeren, en door dit te combineren met een KBV, heb ik kunnen onderzoeken hoe zulke management uitdagingen in de praktijk worden benaderd.

Onderzoeksmethoden

De algemene onderzoeksvraag van dit proefschrift is exploratief van aard en dit behoeft een kwalitatief onderzoeksmodel. Hiervoor heb ik in 4 verschillende organisaties primair semigestructureerde diepte-interviews gehouden, en secundair data verzameld vanuit documentatie, vergaderingen, en observaties. Deze data is rijk genoeg om inductief inzicht te krijgen in het onderwerp van dit proefschrift, iets wat met puur deductief kwantitatief onderzoek niet bereikt kan worden. Door data te verzamelen in meerdere organisaties, op verschillende locaties en in verschillende projecten, ben ik tot rijk beschreven inzichten gekomen waar het
onderzoekeveld rondom kennis en R&D werk om vraagt (waar voor het merendeel kwantitatief onderzoek wordt gedaan).

Elke studie in dit proefschrift bestaat enerzijds uit een zoektocht naar patronen en structuur in de data, en anderzijds uit een generalisatie met bestaande theorie, om op deze manier tot nieuwe inzichten te komen. Veelal begonnen de verschillende studies met een algemeen onderzoeksmodel, en werd er gaandeweg aan dit model geschaafd als de data dit toeliet. Op deze manier heeft elke studie een eigen bijdrage aan de algemene onderzoeksvraag.

In totaal zijn er 65 diepte-interviews gehouden. Tabel 1.2 op blz. 18 geeft een overzicht. Het merendeel van de interviews zijn face-to-face afgenomen, op de werkplek van de geïnterviewden in Nederland, Canada, en de VS. De interviews zijn volledig getranscribeerd en gecodeerd aan de hand van software. Analyse hierop volgend is gedaan in samenwerking met het onderzoeksteam, relevante theorie, de geïnterviewden, de organisaties zelf, en aan de hand van reviews bij wetenschappelijke tijdschriften en congressen.

**Studie 1 (hoofdstuk 2): 'Knowledge integration in global R&D networks'**

De eerste studie in dit proefschrift richt zich op het managen van kennis in verspreide R&D, bekeken vanuit een managementperspectief. Dit onderzoek geeft inzicht in de volgende vraag: *Welke factoren zijn van invloed op kennisintegratie binnen verspreide R&D?* De studie bespreekt de basis van de 'knowledge-based view' en het 'practice-based' perspectief en gaat in op specialisatie en integratiedoelstellingen van de organisatie. Aan de hand van een model vanuit de literatuur wat kennismanagementonderzoek onderverdeeld in een focus op unit-niveau (locatie), een focus op kennis, en een focus op de relatie tussen units waarin kennis wordt gedeeld, worden er verschillende factoren geïdentificeerd vanuit de analyse op interviews in 4 organisaties (zie tabel 2.1 blz. 27).

De contributie van de studie is tweeledig. Ten eerste complementeert de studie voorgaand onderzoek naar kennismanagement in verspreide R&D door op drie niveaus belangrijke uitdagingen voor management te identificeren. Ten tweede wordt er voor elk niveau een brede managementaanpak beschreven. Enerzijds beschrijven de interviews top-down, meestal
formelere manieren van het managen van kennis. Anderzijds wordt er nadruk gelegd op een meer bottom-up manier van kennis managen, waarbij verschillende managementtaken en uitdagingen met elkaar worden vergeleken en er meer aangepast management plaatsvindt. De studie gaat in op het bewust managen van de praktijk waarin R&D werk zich afspeelt, waardoor er concepten zoals kennis inbedding en verschillende manieren van management aan het licht komen en worden besproken. Deze concepten worden gebruikt als vertrekpunt in de volgende studies.

Studie 2 (hoofdstuk 3): 'Boundary objects in new joint fields'
Studie 2 bouwt voort op studie 1 en beschrijft een specifiek project tussen een Nederlandse en een Canadese R&D afdeling van een multinational gespecialiseerd in printtechnologie. De studie beschrijft hoe een stuk software, wat in het verleden succesvol in andere contexten is gebruikt, soms moeilijk overdraagbaar kan zijn naar gedeelde (samenwerkings-) contexten. Meer specifiek beschrijft deze studie hoe een ontwerpsysteem dat door de jaren heen zo ingebed is geraakt in zijn eigen lokale omgeving, bij verplaatsing naar een gedeelde context (in dit geval een gedeeld project) eerder samenwerking tegengaat dan bevordert. Dit argument wordt geïllustreerd aan de hand van CAD-ontwerpsoftware en het gebruik van wiki's, en laat zien dat 'samenwerkingsobjecten' die voorheen effectief waren, verschillende uitkomsten kunnen hebben op gedistribueerde samenwerking.

De analyse van de studie gaat in op de aanwezigheid van een gedeelde sociale en praktische context waarin complexe kennis, know-how, en ervaring met het ontwikkelen van nieuwe technologieën kan worden gedeeld. Omdat zo een gedeelde context in verspreide R&D moeilijk kan worden gerealiseerd, is het belang van het kijken naar objecten die samenwerking kunnen realiseren (zoals software) groot. De studie resulteert in twee duidelijke contributies. Ten eerste laat de studie zien dat het succes van zo een samenwerkingsobject afhangt van wat voor soortgelijke objecten er al worden gebruikt, en ook hoe zo een object zich historisch heeft gevormd in een lokale context. Ten tweede laat de studie zien dat een nieuwe projectomgeving niet altijd betekent dat deze omgeving voor iedereen neutraal is. Het invoeren van samenwerkingsobjecten vanuit een van de lokale contexten kan zowel van positieve als negatieve invloed op de ontwikkeling van een gedeelde context zijn.
Studie 3 (hoofdstuk 4): 'Knowledge pollination: facilitating organizational learning in geographically dispersed settings'

Studie 3 gaat in op het belang en tegelijkertijd de complexiteit van lokaal ingebedde kennis. Aan de hand van een studie naar experts binnen een organisatie gespecialiseerd in energiewinning en verwerking, identificeer ik een proces wat ik 'knowledge pollination' (kennisbestuiving) noem. De studie rapporteert hoe een gevestigd maar flexibel netwerk van kenniswerkers kan faciliteren in het verspreiden van lokaal ingebedde kennis, door deze kennis als het ware te verstuiven tussen verschillende locaties. Deze experts werken in verschillende lokale contexten, waardoor zij per context hun eigen kennis toepassen en tegelijkertijd nieuwe kennis bijleren. Deze ervaring nemen zij dan weer mee en passen deze (deels) toe in de volgende opdracht in een andere context, enzovoort.

De studie draagt bij aan theorie door het concept 'knowledge pollination' te introduceren als een bottom-up en veelal onbewust proces dat organisatie-breed leren kan bevorderen. Door hierin concepten als georganiseerd leren, leren in de praktijk, en 'transactive memory' (bij wie in de organisatie is welke kennis te vinden) te bespreken, draagt het bij aan een bredere kijk op kennisdeling in verspreide organisaties. Hiernaast geeft de studie nieuw inzicht in het concept 'knowledge embeddedness' (ingebedde kennis). De analyse biedt een micro-perspectief op hoe ingenieurs expertise opbouwen, en relateert dit aan een macro-perspectief op hoe deze experts de organisatie kunnen faciliteren in het managen van ingebedde kennis.

Studie 4 (hoofdstuk 5): 'Specialization and integration in dispersed R&D settings'

Studie 4 richt zich specifiek op de spanning tussen kennispecialisatie en kennisintegratie in verspreide R&D. Integratieactiviteiten kunnen positief zijn voor specialisatie, doordat er kennis kan worden gecombineerd en nieuwe specialisatie ontstaat. Aan de andere kant kan een grote druk op integratie het emergente proces van R&D werk in de weg staan waardoor specialisatie niet van de grond komt. Andersom bekeken is er specialisatie nodig om vervolgens nieuwe kennis te kunnen integreren. Rekening houdend met processen die specialisatie tot stand brengen,
zoals context specifiek leren (situated learning), en processen die integratie bevorderen, zoals road mapping (strategiebepaling) in de bredere organisatie, identificeert deze studie verschillende managementuitdagingen die zowel relateren aan specialisatie als aan integratie. Deze uitdagingen worden uitgebreid besproken en geïllustreerd aan de hand van verschillende voorbeelden vanuit de data.

De algemene contributie van deze studie is een overzicht van verschillende specialisatie- en integratietenden en hun relatie in de praktijk. Deze studie draagt bij aan theorie door meer inzicht te geven in niet alleen een managementperspectief maar ook een praktijkperspectief op het managen van kennis in verspreide R&D. De analyse gaat uitgebreid in op de behoeften van ingenieurs om samenwerking tot stand te brengen (wat resulteert in context specifiek leren en specialisatie), en het gaat in op hoe kennisintegratie zulke behoeften kunnen faciliteren of juist tegenwerken, en andersom, hoe specialisatie kan bijdragen aan integratie.

**Bijdragen van het onderzoek**

De studies samen beschrijven drie brede uitdagingen voor management: de uitdaging om de spanning tussen specialisatie en integratie te managen, de uitdaging om ingebedde kennis te managen, en de uitdaging om processen voor kennisdeling op een goede manier te managen.

De eerste uitdaging wordt al in de introductie van het proefschrift besproken. Om specialisatie in gedistribueerde samenwerking te laten plaatsvinden, bijvoorbeeld in een gedeeld project tussen locaties, is er een vorm van kennisintegratie tussen locaties en mensen nodig. Voor het ontwikkelen van organisatie-brede kennis is er weer een andere vorm van integratie nodig. De uitdaging van het tegelijk managen van specialisatie en integratie is om beide processen gebalanceerd maar effectief te managen, zodat zowel specialisatie als integratiedoelstellingen worden gerealiseerd. Beide processen worden uitgebreid in management- en organisatieliteratuur besproken, waarbij de focus meestal op een van de twee processen ligt. In dit proefschrift zijn de twee processen niet apart van elkaar onderzocht, maar in relatie tot elkaar waardoor precies de momenten worden belicht waarin specialisatie en integratie elkaar beïnvloeden. Deze focus brengt 2 duidelijke contributies met zich mee. Ten eerste wordt er in de studies een vergelijking
gemaakt met centraal georganiseerde R&D en komt hier uit voort dat door een gedeelde sociale en praktische context kan faciliteren in het managen van de spanning tussen de twee processen van specialisatie en integratie. Dit heeft drie onderliggende gedachten. Specialisatie en integratie zijn beide processen die in centraal georganiseerde R&D voor een groot gedeelte op natuurlijke wijze plaatsvinden doordat mensen elkaar vaker zien, elkaars expertise beter kennen, en er meer formele en informele face-to-face interactie is waarin kennis wordt gedeeld. Een gedeelde context zorgt dus er dus voor dat de spanning tussen specialisatie en integratie verminderd wordt. Ten tweede zorgt een gedeelde context er voor dat er minder top-down gemanaged hoeft te worden omdat er in onderling makkelijker afgestemd kan worden tijdens het werk zelf. Bevindingen laten zien dat dit ook in verspreide R&D zelfgeorganiseerd kan zijn, maar dit verloopt minder natuurlijk dan in centraal georganiseerde R&D. Ten derde kan interactie tussen specialisatie en integratie in de praktijk er voor zorgen dat beide processen gerealiseerd worden, aangezien (gekeken naar de kenmerken van R&D werk: integraal, context gebonden, en emergent) een dynamische combinatie van de twee zorgt voor ontwikkeling van nieuwe kennis. Hoewel het belang van een gedeelde context voor het ontwikkelen van nieuwe kennis veelvuldig is besproken in de literatuur, is zo een context niet eerder besproken in verhouding tot de spanning tussen specialisatie en integratie. De studies in dit proefschrift laten zien dat een gedeelde context duidelijk van invloed is op de spanning tussen specialisatie en integratie, en daarom belangrijk om binnen deze managementuitdaging te bespreken. De tweede contributie vanuit het onderzoeken van specialisatie en integratie is de bespreking van deze concepten op en tussen verschillende organisatieniveaus. Bespreking van specialisatie en integratie op deze verschillende niveaus is nog niet eerder gedaan. Dit draagt bij aan het begrip van de relatie tussen corporate R&D en midden- en lokaal management in R&D. Specialisatie is besproken op lokaal niveau als een proces met veel zelforganisatie, terwijl specialisatie in verspreide samenwerking meer management nodig heeft om een gedeelde context te realiseren. Uit de studies komt naar voren dat deze vorm van management er voornamelijk op gericht moet zijn om connecties tussen mensen plaats te laten vinden, en niet zozeer om het integreren van de kennis zelf - dit gebeurt namelijk tijdens het werk zelf, als er voldoende gedeelde context is om samen te werken. Kennisintegratie op lokaal niveau is op zijn beurt besproken als iets dat zowel formeel als informeel georganiseerd is. Integratie in verspreide samenwerking is evident voor het creëren van
een gedeelde context, zodat specialisatie kan plaatsvinden, maar moet op zo een manier worden ingericht dat specialisatie ook de ruimte krijgt om van de grond te komen. Kennisintegratie op organisatieniveau staat dan weer wat verder af van het specialisatieproces, maar kan toch specialisatie en integratie op lagere niveaus belemmeren.

De tweede uitdaging gaat over het managen van ingebedde kennis in de organisatie. Dit concept *(knowledge embeddedness)* komt in alle 4 de studies als een centraal thema naar voren. De uitdaging bestaat allereerst uit het goed begrijpen van de waarde van ingebedde en context-specifieke kennis, en daarnaast uit het op de juiste manier omgaan met deze kennis. De uitdaging is in verspreide R&D groot omdat ingebedde kennis het beste in een fysieke, sociale en praktische context kan worden gedeeld, wat bij verspreide samenwerking vaak moeilijk te realiseren is. De bevindingen in de verschillende studies beschrijven hoe een specifieke context eigenlijk onderdeel is van de kennis die daar in wordt gecreëerd en dat deze context meegerekend moet worden als management op kennisintegratie stuurt. Deze gedachte gaat er van uit dat er dus minder alleen naar kennis gekeken moet worden en meer naar de praktijk waarin die kennis ingebed is. De tweede contributie voor de literatuur laat zien dat ingebedde kennis zowel positief als negatief voor de organisatie kan zijn. Er worden voorbeelden besproken waarin ingebedde kennis waardevol is en voorbeelden waarin ingebedde kennis juist samenwerking verhinderd. Meer specifiek beschrijf ik ingebedde kennis vanuit een 'practice-based' perspectief, en dit relateer is aan specialisatie en integratie, concepten vanuit de 'knowledge based view'. Hierdoor verbind ik een concept wat wordt beschreven als iets wat 'spontaan' gebeurt in de praktijk aan duidelijke en directe managementdoeleinden, wat het concept verrijkt met een managementperspectief.

De derde uitdaging beslaat het managen van mechanismen rondom kennisdeling *(managing knowledge transfer mechanisms)*. De bevindingen in dit proefschrift geven duidelijk aan dat de standaardprocessen om kennis te delen in centraal georganiseerde R&D niet voldoen voor kennisdeling in verspreide R&D. Er wordt in de praktijk veel nadruk gelegd op ICT, terwijl ICT enkel een deel van de processen om kennis te delen beslaat. In de studies wordt een scala aan middelen besproken, formeel en informeel, die zich richten op niet alleen kennis, maar ook de werkzaamheden en context waarin kennis zich bevindt. De bevindingen bespreken hoe
management zich bewust kan worden van verschillen tussen contexten zodat er op de juiste kennisprocessen aangestuurd kan worden. Hiernaast wordt er uitgebreid ingegaan op zowel formele als informele vormen van kennisoverdracht die in de verschillende casestudies naar voren kwamen.

De implicaties voor de praktijk zijn meervoudig. De verschillende studies en de discussie in hoofdstuk 6 dragen bij aan een breder inzicht in verschillende soorten uitdagingen voor management in verspreide R&D. Door de hoofdstukken heen worden er verschillende voorbeelden besproken. Verder wordt er duidelijk onderscheid gemaakt tussen centraal georganiseerde en verspreid georganiseerde R&D, waardoor er inzicht wordt verkregen waar op te letten en waar anders te organiseren als R&D werk of R&D management van centraal naar verspreid over gaat. Hiernaast wordt er ingehaakt op de formalisatie die vaak optreedt als R&D verspreid wordt georganiseerd. Formalisatie wordt vaak versterkt om het gemis van een fysieke en informele omgeving op te vangen, maar gelet op de flexibiliteit die R&D processen behoeven, kan deze formalisatie ook negatief uitpakken.

Meer specifiek kan ik drie duidelijke bijdragen onderscheiden. Ten eerste maakt het 'practice-based' perspectief het mogelijk om in de verschillende casestudies de ontwikkeling van ingebedde kennis te beschrijven, waardoor het duidelijk wordt op wat voor manier kennis is ingebed. In de tweede studie beschrijf ik bijvoorbeeld hoe een CAD systeem ingebed is geraakt in een bepaalde context waardoor het moeilijk te gebruiken was in een nieuwe samenwerking met andere locaties. Deze bevindingen geven niet zozeer aan wanneer management welke processen voor kennisdeling zou moeten aansturen, maar maakt vooral duidelijk dat er in een bredere zin naar ingebedde kennis gekeken moet worden: Hoe is het tot stand gekomen, hoe gebruiken mensen het in hun werk, en met welk doel moet kennis gedeeld worden en wat voor processen sluiten hier bij aan. Een tweede bijdrage is de beschrijving van verschillende soorten kennisdelingsprocessen in relatie tot elkaar. Zo zullen 'boundary objects' (samenwerkingsobjecten) een directer effect hebben op integratie en specialisatie op meer praktische niveaus, terwijl 'knowledge pollination' (kennisbestuiving) hier minder snel effect sorteert maar meer effectief kan zijn voor organisatie-breed leren. Alternatief kan kennisbestuiving er voor zorgen dat er meer gedeelde context in een organisatie ontstaat,
waardoor kennisintegratie en specialisatie op lagere niveaus beter van de grond komen. Als samenwerkingsobjecten effectief zijn ingericht in verspreide R&D, kan dit op zijn beurt het kennisbestuivingsproces faciliteren. Een derde bijdrage is te vinden in het beschrijven van duidelijk informeel ontstane kennisdelingsprocessen. Studie 3 laat bijvoorbeeld zien hoe kennisbestuiving ontstaat tijdens het werk zelf, door een combinatie van georganiseerd leren, leren in de praktijk, en 'transactive memory', en hoe dit effectief werkt als een kennisdelingsproces. Dergelijke informele processen zijn geïdentificeerd door te kijken hoe engineers en kennis zich in de praktijk van de organisatie gedragen. De praktische bijdrage hiervan richt zich op de gedachte om bij kennisdeling in de organisatie niet alleen te kijken naar formele manieren van kennisdelen die ingevoerd zouden kunnen worden, maar om vooral ook te onderzoeken op wat voor manieren er op natuurlijke wijze kennis wordt gedeeld en hoe dit te cultiveren en te faciliteren, zelfs in een verspreide organisatie.
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