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Citation

Sole, Deborah, and Amy Edmondson. 2002. "Situated Knowledge and Learning in Dispersed Teams." *British Journal of Management* 13 (S2): S17–34. <https://doi.org/10.1111/1467-8551.13.s2.3>.

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SITUATED KNOWLEDGE AND LEARNING IN DISPERSED TEAMS

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Abstract

This qualitative field study explores how geographically dispersed teams draw on knowledge situated in the multiple physical locales they span, to learn and accomplish their collective work. We propose the construct of *situated knowledge* as important for understanding the learning process in dispersed teams. Qualitative data collected on seven new product/process development projects, each spanning multiple sites, reveal that situated knowledge is both a blessing (a valuable resource) and a curse (a source of communication difficulty) for dispersed teams. On the one hand, dispersed teams can leverage local competencies and resources because team members understand and participate in local practices. On the other hand, dispersed teams may not be able to use specialized knowledge held by remote team members unless they recognize and adjust for local inflections that give meaning to that knowledge. The paper reports on analyses of 44 learning episodes involving the use of situated knowledge, and draws from these data to suggest critical factors involved in ‘liberating’ situated knowledge and putting it to use. Implications for research and practice are discussed. (174)

April, 2001

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1 INTRODUCTION

The notion of knowledge as a source of organizational advantage is by now well accepted, and much of the focus of current organizational research has shifted to understanding *how* organizations create, transfer, and deploy knowledge (Argote, 1999; Argote & Ingram, 2000). Understanding how knowledge is created and applied effectively in new product development is of particular interest, because the ability to rapidly and consistently deliver innovative products is critical to organizational success in changing environments (Drucker, 1993; Teece & Pisano, 1994). New knowledge is often created as a result of combining previously unconnected bodies of knowledge or combining existing knowledge in novel ways (Grant, 1996; Kogut & Zander, 1992; Schumpeter, 1934). Managers thus have sought organizational designs and processes that facilitate combining and exchanging knowledge in organizations. One such design is a geographically dispersed, cross-functional team—increasingly espoused for enhancing knowledge creation and innovation, especially in research and development activities (e.g. Boutellier, Gassmann, Macho, & Roux, 1998; De Meyer, 1993a, 1993b; Gorton & Motwani, 1996; Leonard, 1995; Madhavan & Grover, 1998; Prokesch, 1997).

Despite the multiple promises of dispersed development—better understanding of global clients, operations, and suppliers (Boutellier et al., 1998), improved project productivity through around-the-clock work patterns (Gorton & Motwani, 1996), and enhanced learning (De Meyer, 1993a; Prokesch, 1997)—evidence suggests that combining knowledge in dispersed, cross-functional teams may be inherently problematic. First, cross-functional teams are expected to deliver rapid, creative, and flexible responses to challenging development needs, because they can bring diverse expertise and perspectives jointly to bear on issues (Brown & Eisenhardt, 1995; Leonard, 1995; Madhavan & Grover, 1998). In practice, however, team members with different occupations or from different functions struggle to understand each other, leading to misinterpretations and occasionally to conflict (Bechky, 1999; Dougherty, 1992). Second, despite the appeal of seeking increasingly specialized knowledge from members in different sites with unique industrial competencies (Leonard, Brands, Edmondson, & Fenwick, 1998)—as well as from different functions and occupations—research on knowledge and innovation management, together with studies of virtual teams, suggest that knowledge does not always ‘flow’ easily across locations or subunits (e.g. Argote & Ingram, 2000; Hansen, 1999; Lam, 1997; Szulanski, 1996; von Hippel, 1994; Zander & Kogut, 1995). These difficulties have in part been attributed to knowledge being “sticky” (von Hippel, 1994) or tacit (Polanyi, 1966). Yet, perspectives that focus on inherent properties of knowledge as a source of inertia fail to explain why sometimes knowledge flows or ‘leaks’ (e.g. within functions), and at other times it ‘sticks’ (e.g., across functions) (Brown & Duguid, 2000). This paper focuses instead on the relationship between knowledge and the activities of those who use it, to develop a fuller understanding of how knowledge can be accessed, combined, and developed in dispersed teams.

Different conceptualizations of knowledge yield different insights about innovation, product development, and knowledge creation in organizations, and a “practice” perspective has been suggested a way of reconciling conflicting findings (Brown & Duguid, 2000). Building on this suggestion, we adopt a practice perspective in a longitudinal, qualitative field study of seven geographically dispersed, cross-functional new

product/process development teams in a single firm. This perspective led us to focus on how work was actually accomplished in the different sites in which team members were based, which drew our attention to how knowledge was situated in a given locale, or organizational site. This paper thus develops insights about how dispersed teams learn and create new knowledge by focusing on how team members negotiated site-based boundaries of knowledge and practice. We conceptualize learning in these dispersed teams as the acquisition of knowledge and experience that enables a team to address project tasks and issues for which solutions were not previously obvious.

Our analysis suggests that *situated knowledge* is critical to learning in a dispersed team, and also that this critical source of knowledge is discovered and applied in different ways. On the one hand, dispersed teams can leverage local skills and resources because local team members readily perceive the potential relevance of local knowledge and are able to apply it by virtue of participating in and understanding site-specific practices. On the other hand, dispersed teams may not be able to benefit from the specialized knowledge of remote team members unless they can recognize and adjust for site-specific practices and structures within which that knowledge is embedded. The present study thus finds, not surprisingly, that dispersed team learning frequently depends on physical movement of key members to ‘liberate’ their situated knowledge for application elsewhere. When individuals were able to re-situate this potential source of knowledge, their teams were better able to respond.

In the next section we discuss elements of a practice perspective and how it shapes our investigation of knowledge sharing. We then elaborate on the construct of situated knowledge and offer a formal definition. The following section describes the research setting and methods. Subsequently, we present our findings and discuss how situated knowledge and practice play out in the activities of dispersed development teams. We conclude by discussing some of the implications of situated knowledge for dispersed development teams, and for dispersed work more generally.

2 PRACTICE AND SITUATED KNOWLEDGE

A practice-based perspective (Bourdieu, 1977; Brown & Duguid, 1991; Lave & Wenger, 1990; Wenger, 1998) emphasizes the collective, situated, and provisional nature of knowledge, as a contrast to a rational-cognitive view of knowledge. Central to the practice perspective—and to related theories emphasizing work activity (Blackler, 1993; Engestrom, 1993)—is acknowledgement of the broader social and structural contexts in which individual actions take place; these bodies of work view learning as inseparable from context. These researchers thus investigate the interaction between individuals and their community (or social context), the interaction between individual actions and the environment (or physical context), and the roles played by resources such as physical and abstract tools and procedures in these interactions. Contextual elements are seen to shape how individuals learn to become knowledgeable and competent at a certain practice or activity in a particular context. The present study builds on the practice literature, to examine how the context dependence of organizational work practices affects knowledge sharing and learning in dispersed teams.

The concept of practice connotes *doing*—doing in both historical and social contexts that give structure and meaning to what is being done (Wenger, 1998, p47). Practice involves both explicit and tacit elements. It includes easily identified language, tools, concepts, roles, and procedures, as well as more implicit elements such as rules of thumb, embodied capabilities, and shared worldviews. A practice perspective pays attention to actions and how these both enact and create social structures. The practice lens offers insights into the *dynamics* of knowing and learning in organizations, by focusing on the way work gets done and on how knowledge is generated and applied in the process. This perspective highlights how divisions of knowledge form as a result of the division of work and thereby give rise to boundaries between groups (or communities) involved in different work activities. Greater or less ease in communicating knowledge in organizations is thus explained not in terms of inherent properties of knowledge itself but rather in terms of crossing epistemological boundaries associated with different practices (Brown & Duguid, 2000). Consistent with this, we seek to understand how knowledge differences might develop between sites, as well as how such knowledge is developed, exchanged, and applied in dispersed teams.

2.1 Communities of Practice

The construct of “communities of practice”—interdependent practitioners having common work practices, a common interpretation of their joint endeavor, and shared epistemic perspectives—has been suggested as a lens (and unit of analysis) for understanding learning, work, and the development of identity in organizations (Brown & Duguid, 1991; Lave, 1991; Wenger, 1998). Most prior empirical studies have focused on *role-based* communities of practice where members engage in similar jobs or occupations. Examples include studies of the work and knowledge of butchers and midwives (Lave & Wenger, 1990), medical claims processors (Wenger, 1998), photocopier repair technicians (Brown & Duguid, 1991), and engineers, technicians and assemblers (Bechky, 1999). A few organizational studies have identified *task-based* communities of practice, where members playing different roles are still engaged collectively and over time on particular tasks (e.g. Robey, Khoo, & Powers, 2000). The present study, in contrast, identifies locale or site as a source of shared work practices and resources, objectives, and identity. Site-based shared knowledge can transcend both role and task boundaries, as we illustrate below. This section considers dimensions of practice identified by Wenger (1998)—shared endeavors, mutual engagement, and a shared repertoire of resources—to propose implications of site-based differences for the work and learning of dispersed teams.

A shared endeavor. Practice encompasses an endeavor in which practitioners experience meaning in what they do, and a *communities of practice* lens highlights social configurations within which individuals pursue a shared enterprise, and assist each other to become competent in that enterprise (Wenger 1998). Membership in the practice is defined through one’s participation in such work and through one’s mutual engagement with and commitment to others who pursue the same objective. The incentive to participate is based on the desire to solve problems, develop skills, and build relationships. Newcomers participate peripherally until they become legitimate members by demonstrating their competence in the practice (Lave & Wenger, 1990). Membership is thus a process of legitimization, rather than an automatic or instantaneous step. As members of a practice, individuals work interdependently on a collective endeavor and thereby develop a shared

identity. Members outside a particular practice often feel alienated because they do not comprehend the value of the endeavor. In this way, the boundaries of a practice are indicated by a sense of belonging or a lack thereof.

In a similar way, membership in a particular geographic sub-unit can influence members' interpretations of what is distinctive, central, and enduring about what they do, and organizational sub-identities often exist based on geographic location (Fiol, 1991). For example, in a matrix organization, co-located organizational members often share regional responsibilities—constituting a shared endeavor. Social identity theory also suggests that the relatively greater common knowledge about co-located colleagues and local activities compared to those elsewhere might prompt the development of a social identity based on organizational locale (Tajfel, 1981).

Mutual engagement in practice. Practice does not emerge merely from a collection of individuals performing similar or related tasks, but rather through the interdependent activities of a group who collectively perceive those activities as worthwhile. Brown and Duguid (1991) show how individuals in organizations act interdependently to accomplish work—often contradicting canonical views of their work as being independent and individually-oriented. When people work interdependently, they become informally bound to one another through exposure to a common class of problems. They come to embody a store of shared knowledge informally disseminated through frequent interaction in the course of addressing these mutual problems. This process is conveyed in reports of photocopier repair technicians telling stories of their past experiences when faced with unexpected, non-documented problems (Brown & Duguid, 1991; Orr, 1990). Through story telling, individuals in the community were able to learn from the experience of others. Similarly, coworkers in physical proximity who interact frequently and learn from each other to solve problems (Allen, 1977), can share knowledge and practices that are not available to remote colleagues.

Practices evolve through the mutual engagement of participants in pursuit of a shared objective. Similarly, co-located colleagues who interact with each other in systematic ways towards common purposes over time collectively acquire knowledge of 'the way things get done around here' (Badaracco, 1991; Collins, 1983; Granovetter, 1985; Kogut & Zander, 1992; Levitt & March, 1988; Nelson & Winter, 1982). They subsequently draw on this knowledge of practice to accomplish efficient and effective communication and action within the setting. Because this knowledge is learned over time, it is unlikely to be shared by dispersed group members who have not interacted previously or extensively. In addition, because participants in a particular work setting themselves gradually take this knowledge for granted, they often cannot readily isolate their knowledge and practices, nor articulate its relevance to colleagues from other locations (Rennecker, 2001). Therefore, knowledge of certain work practices is likely to be situated in a physical (and social) setting where frequent, casual interaction takes place. Implicit assumptions associated with particular actions or decisions may remain largely obscured to participants in other locations. Different assumptions, manifest in communication misunderstandings, are therefore likely to signal a boundary of practice and knowledge.

Shared repertoire of resources. Practice includes shared historical social and physical resources that sustain and shape mutual engagement in action (Wenger, 1998, p5). 'Resources' is interpreted as a means of supplying what is needed to accomplish work,

rather than a particular physical asset. These include rules, roles, and procedures that shape how community members interact together on work tasks, as well as physical and conceptual tools that trigger and enable particular approaches to tasks.

In the mutual pursuit of solutions to common problems, co-located individuals draw on colleagues' competencies without explicitly recognizing that or how they know about this source of expertise. Proximity also allows others to recognize the existence of knowledge—such as competence to use a tool or machine—that cannot be fully codified in words, symbols or procedural instructions. Such knowledge can be recognized, and even shared, when colleagues are able to engage in dialogue, observation, and shared activity (Leonard-Barton, 1992; Nonaka & Takeuchi, 1995). Through proximity-based interactions, individuals develop “transactive memory” (Moreland, 1999; Wegner, 1987)—knowledge of what others know. Because knowledge of local expertise is acquired gradually and informally, it is unlikely to be discussed or documented explicitly. In this way, we suggest that awareness of colleagues' expertise and competencies can become situated in a physical setting, and that, in the absence of intentional intervention, this kind of expertise is unlikely to be easily visible or accessible to remote members.

Other resources of practice include tools, techniques and technologies to accomplish work, as well as terminology to describe and discuss that work. Concrete resources such as tools, equipment, and materials make up the physical setting, and these often differ from site to site, even within the same firm. Physical equipment, artifacts, and the use of physical space have been shown to provide both cues and constraints for learning (Brown & Duguid, 1991; Fleck, 1997; Tyre & von Hippel, 1997; von Hippel & Tyre, 1995). Knowledge to act effectively in a particular setting is difficult to share because remote others do not experience those same physical cues. In a study of technology-enabled dispersed student teams, Cramton (2001) found that, despite having similar educational backgrounds, team members lacked “mutual knowledge” of the local work patterns and information technology resources that constrained each individual's interactions with the virtual team. This lack of shared knowledge hindered their ability to identify the root causes of miscommunications and develop effective teamwork practices. In contrast, when people can interact—within a specific context, confronted with unique sources of information, experiencing different constraints, with access to particular tools to solve problems—learning is enhanced (Brown & Duguid, 1991; Tyre & von Hippel, 1997; von Hippel & Tyre, 1995). Language is another resource, often determined by location, that can be unique to a practice. For example, Bechky (1999) documented how two communities of engineers and assemblers evolved different terminology and worked with different artifacts to fit their occupational work contexts. Their different use of these resources hindered communication across the boundaries of their practice, such that they required mediators (technicians) to facilitate exchange of their respective knowledge.

Location-based differences in repertoires of resources are likely to shape how work is accomplished in different places and to affect what resources come to mind for solving problems. Since practice evolves to accomplish ‘real work’ effectively (Brown & Duguid, 1991; Orr, 1990), it adapts to local resource constraints and takes advantage of local resource opportunities. Orr's (1990) classic account of photocopier repair technicians documents how this CoP developed work practices that satisfied their local needs and often ignored or neglected the formally prescribed procedures because these were seen as less relevant to performance. Thus we might expect that organizational members in one locale

develop practices and draw on resources that differ from those of other organizational locales—even if members from both locales were engaged in similar occupations or part of the same function.

2.2 Situated Knowledge

Previous work thus maintains that communities of practice share knowledge of community competence, appropriate problem-solving approaches, and available resources—as a result of shared work practices. This paper extends this line of thinking to suggest that members of dispersed teams can similarly develop knowledge as a result of exposure to work practices in their different locations. That is, an important component of what dispersed team members individually know is *situated* in their different social and physical contexts. We focus on these contextual elements in our analysis of the data to examine how dispersed team members negotiate this situated knowledge.

We define situated knowledge as knowledge embedded in a physical site or location. For example, in a manufacturing facility, situated knowledge might include special knowledge about supplier reliability, about the performance of a particular piece of equipment, or about who knows what. Situated knowledge is similar to Fleck's (1997) concept of contingent knowledge in being contextually embedded. However situated knowledge is considered embedded in a particular physical location rather than in a general working milieu—such as a laboratory—that may recur in different places. It is also lasting—relevant over long periods of time rather than primarily during the implementation of a new technology or project. In contrast to knowledge shared by members of a functional group (Dougherty, 1992) or a community of practice (interacting around common work), situated knowledge may be shared by those who are co-located, despite role or task-based differences. This kind of knowledge tends to be taken for granted by those working in the site, and hence is likely to be difficult to access, without some intervention to catalyze a process of liberating it.

The aim of this paper is to argue that situated knowledge plays an important role in the process and effectiveness of knowledge sharing and learning in dispersed teams, and to suggest critical factors that allow such teams to put situated knowledge to use.

3 METHODOLOGY

We conducted a longitudinal qualitative study of working and knowledge sharing practices of seven geographically dispersed, cross-functional development teams in a single organization. The goal of the study was to explore the processes of creating, sharing and applying knowledge in pursuit of innovation when team members come from different physical and intellectual backgrounds. Because our objective was to generate rather than test theory, the study design was open-ended to allow unforeseen themes to emerge from the data. As discussed above, our thinking about situated knowledge and its potential relevance was triggered by the literature. This interest was enhanced by themes that emerged in the data, which highlight the role of site-based knowledge and practices in the work of dispersed teams.

3.1 Research Setting

We studied geographically dispersed, cross-functional teams at DevCo (a pseudonym), a multinational manufacturing company designing and producing polymer products for use in industrial and consumer applications. DevCo employed over 4000 people worldwide and company revenues exceeded \$1 billion per year. The company, formed as the result of an earlier acquisition and a subsequent joint venture, relied heavily on teams staffed from different research centers, production sites, and commercial offices around the world for new product and process development. At the time of data collection, this practice had been in use across some sites for a number of years and had become more widespread and frequent.

Project teams were selected both for their similarities and their differences, following guidelines for theoretical sampling (Glaser & Strauss, 1967; Yin, 1994). Teams were added to the study in phases, which allowed for progressive refinement of the conceptual model. Initially, two development teams were selected whose projects were at equivalent stages of the company's standard "stage-gate" development process. Both developments were significant in terms of investment, risk, and complexity. The projects differed in terms of the particular physical sites involved and the longevity of the teams. Both teams had representation from commercial, technical, and production areas, and included key participants from at least three physical locations. Subsequently, we added five additional development projects, providing further variation on group tenure and task complexity—two variables suggested by the group literature as important in shaping group processes (Goodman, Ravlin, & Argote, 1986; McGrath, 1984). Although the study design presented a potential confound between broad functional groups (commercial, technical, and production) and geographical site, most sites included two or three functions, such that it was possible to distinguish between functional boundaries and site-based boundaries.

All teams had cross-functional representation but varied in project complexity, creating implications for interdisciplinary collaboration. Teams also differed in the extent of their geographical distribution—for example, some teams included members in Asia, America and Europe, others spanned only European locations—and thus in the ease with which they might occasionally meet face to face. Teams had access to a range of technological tools to support their collective work, including those allowing "same time, different place" interactions – audio-conferencing, video-conferencing, application sharing – and "different time, different place" interactions –electronic messaging, computer conferencing (threaded discussions), workflow organization, and shared, structured document repositories. Although they had access to the same set of information and communication technologies (ICTs), the teams did indeed differ in the way they eventually used these tools². Table 1 describes the project-teams in the sample.

² In this paper, we do not report on the dispersed teams' use of technology.

Table 1 Descriptions of Development Teams and Projects

Project Team	Development Task	Task Complexity ^a	Team Composition	# of Core Members	# of Sites Involved ^b	# of Countries	# of Languages	# of Informants
GROSSO	Develop new product for high-margin market segment using new product and process technology	H	Research Scientist* Experimental Scientist Process Design Engineer Materials Specialist Production Engineer Market Manager	6	4 (+3) SiteC SiteD SiteV SiteW	5	1	8
BIANCO	Develop new product for strategic new customer using combination of existing product and process technologies	MH	Product Development Engineer* Process Team Leader Technical Specialist Research Scientist Market Manager (US) Market Manager (JP) Regional Commercial Manager (JP)	7	5 (+2) SiteB SiteH SiteI SiteT SiteW	3	2	9
CHIARO	Develop replacement products for existing profitable market through novel process technology	MH	Production Development Engineer* Market Development Manager Experimental Scientist Process Design Engineer Production Supervisor Market Manager (EU)	6	3 (+1) SiteD SiteS SiteW	2	1	5
SCURO	Develop replacement products for existing market using combination of existing process technology	M	Production Engineer* Technical Specialist Production Engineer Technical Service Representative Sales Account Manager	5	3 (+3) SiteC SiteG SiteH	2	2	4
GRIGIO	Develop new product for existing customer, using combination of existing process technology	M	Product Development Engineer* Research Scientist Experimental Scientist Process Team Leader Technical Service Representative Sales Account Manager	6	3 (+2) SiteH SiteW SiteX	2	1	7
ROBUSTO	Develop improved process technology for platform production process	M	Research Specialist* Process Specialist Polymer Specialist Production Engineer Production Technician Maintenance Engineer	6	3 SiteC SiteH SiteW	2	1	4
NERO	Develop replacement product for important customer, using existing process technology	L	Application Development Manager* Experimental Scientist Production Engineer Sales Account Manager	4	3 (+1) SiteH SiteW SiteX	2	1	5

a Internal project evaluation criteria.

b Number in brackets indicate close interaction with customers and / or supplier.

* Project team leader.

3.2 Data Sources

We collected data through semi-structured interviews, reviews of organization and project documentation, and through observation of and participation in project-team and organizational activities. This triangulation of various techniques of data collection provided multiple perspectives on issues, and allowed for cross-checking of existing and emerging concepts (Eisenhardt, 1989; Glaser & Strauss, 1967; Pettigrew, 1990).

Interviews. Seventy interviews lasting between one and three hours were conducted with members of the organization engaged in NPD activities, including members engaged in research and development, engineering, technical services, customer service, marketing, sales, and manufacturing. We interviewed managers, team members and peripheral project participants. Most interviews were conducted face to face and were tape-recorded for transcription; the interviewer also took field notes (Gay & Diehl, 1992). Five interviews were conducted by phone; four of these were also recorded. The sample included team members from seven different sites.

Site Data. First, semi-structured interviews were conducted with a cross-section of the NPD organization at one location. Informants were selected from different occupations and organizational levels to provide multiple perspectives into NPD activities and attitudes towards knowledge sharing and collaborative behavior at that location. The interview protocol was designed to elicit information about the nature of development activities and objectives, types of knowledge drawn upon during these activities, the nature of knowledge-intensive interactions, the use of different technologies in knowledge exchanges, and norms of behavior at the site. Cross-sectional interviews were also conducted at a second major development location, yielding insight into similarities and differences in site identities, cultures and norms of behavior. Team members from four other organizational locations and a home-based individual provided additional perspective on these site-level variables. Many informants had worked at sites other than their current location and volunteered information about different perspectives and work practices at these sites by contrasting their current and previous experiences. The idea of site-based practices was strengthened by site newcomers' comments about having to become familiar with local norms and perspectives and feeling that they were initially peripheral players in a novel context.

Project-team Data. Data on projects and teams were gathered primarily through in-depth interviews with team members from various occupations, functional managers overseeing the projects, and additional project support members from multiple locations. These allowed both retrospective and prospective documentation of each project and exploration of knowledge intensive practices both within and across team boundaries. Interviews with management focused on discussion of the teams' performance and project progress. In the interviews with team members (core and peripheral), we sought to derive a general account of the development progress, including key milestone events, from each person's point of view – thus providing a means for comparison of accounts and for generating a baseline account for the group.

We used an adaptation of the critical incident technique (Flanagan, 1954) to retrospectively identify and analyze significant knowledge-intensive episodes during the project. Specifically, we asked interviewees to identify and describe episodes during their project when they felt they had learned something significant or important. Once these events were identified, we probed for factual details about participation, particular behaviors, and specific outcomes, as well as for subjective perceptions, thoughts, and feelings. We use the term ‘episode’ rather than ‘event’ or ‘incident’ because participants told narratives of related activities and decisions unfolding over time that culminated in a particular insight. The start and end of an episode was thus determined by participants’ perceptions, rather than according to a researcher decision. This technique offered a way to learn about specific behaviors and responses in a complex setting. It also provided a way to gather information about typical behavior, grounded in concrete examples.

Review of project and organization documentation. The first author had real-time access to the shared electronic repositories of project and organization documentation during the twelve months of the study. Project electronic archives included minutes of team meetings, project reports and presentations, and feedback from project tasks such as customer visits, analytical evaluations, and manufacturing trials. These documents were prepared by project participants in real-time so they provided a good means to confirm and triangulate against informants’ retrospective reports and observed behavior. In addition, this author received all general email communication sent to the organization as a whole and to the one site with which she was ‘affiliated.’ These data provided additional perspective on management communication practices and policies at DevCo.

Observation and participation. The first author spent approximately two months in the field observing some of the teams in action, and gaining first-hand experience of the different organizational settings. While based at one site for a month, she followed the activities of members of the first two project-teams, ‘observing’ both virtual and physical team interactions in order to gain further insight into how they learned about the needs of their project and approached particular tasks. These observation events included planned face-to-face meetings, teleconferences, casual encounters and conversations, visits to pilot and production facilities, and practical activities such as running experiments. Occasions to observe manufacturing activities on a range of production facilities at one site and to attend an overnight pilot trial by one of the teams at another site provided insight into the production process. Additional insight into different organizational work practices was gained through informal interaction and observation while physically present on site. This included conversations with additional members of the organization (not formally interviewed), participation in discussions and conversations over lunch, attendance of site-level meetings and events, and social excursions with members of the organization.

3.3 Data Analysis

Data collection, coding and analysis proceeded in an iterative fashion (Eisenhardt, 1989; Glaser & Strauss, 1967), with earlier stages of the research being more exploratory and open-ended, and latter stages being guided by the concepts identified in preliminary analyses. We analyzed data within each team as well as across teams, focusing on significant learning episodes; these were identified using collective input from multiple team informants. Online records were then used to corroborate these episodes, and to

develop a single multi-dimensional narrative for each. Often, informants associated learning with successfully passing project milestones, and many of the episodes identified had a strong task orientation. Many of the episodes were salient to informants more for the initial presence of unexpected hurdles than for their successful outcome. In most cases these surprise hurdles were not technical difficulties—which were expected in this kind of work—but misunderstandings as a result of organizational or procedural differences.

Coding of data from the first two teams allowed us to assess whether a distinction between knowledge acquired as a result of what one does (occupational knowledge) and knowledge acquired as a result of where one is (situated knowledge) existed for dispersed development teams. This round of analysis also revealed differences in how the intellectual and physical communities within which dispersed teams were embedded supported the work of these teams (Sole & Edmondson, 2001). Noting that situated knowledge was a key theme in two initial cases of dispersed team learning, we analyzed data from subsequent teams in more detail, paying attention to what aspects of the context were important for teams' learning, and how they identified and used this knowledge.

4 DISPERSED TEAM LEARNING FROM SITUATED KNOWLEDGE

The initial goal of this study was to investigate how dispersed development teams share knowledge, learn, and accomplish their project objectives—rather than specifically to explore the role of situated knowledge. Analysis of data on the significant learning episodes reported by these teams, however, pointed our attention to this highly salient feature of the learning process in these teams. Specifically, over 80% of the 52 learning episodes included what we began to refer to as situated knowledge as a critical element of the narrative. In these 44 episodes, situated knowledge acted as both a barrier to progress and (often later) as a critical input to solving a problem.

Successful use of situated knowledge by dispersed development teams took two forms. One involved the ability of team members to identify and engage knowledge available *locally* (either their own or others'), using this resource to address the dispersed team's *on-site* project needs. The other involved the ability to identify and engage knowledge of team members and colleagues situated *elsewhere*, using it to understand and resolve project issues occurring *locally*. Below we present four (of the 44) episodes to highlight dimensions of situated knowledge and its role in dispersed team learning.

4.1 Two Episodes that Illustrate Teams Leveraging Locally Situated Knowledge

Episode 1: BIANCO "Trial 2." The BIANCO team, dispersed across five sites on three continents, was developing a new product for a new customer in a highly strategic market sector. The product was considered substantially different from existing products because, although its design incorporated known product and process technologies, the team sought to combine these elements in a novel way. The team faced challenging delivery deadlines imposed by the customer. Despite successfully meeting the first (prototype) deadline, the customer—impressed with the work—escalated the product's requirements, pushing for a particular improvement that presented considerable technical uncertainty. Although the team had been exhilarated when the product came out as required, this new challenge was daunting. In an interview, the project leader commented,

So it's around Feb 15 when we got this feedback. Now our next run was approximately Feb 26-27. That gave us two weeks between this new requirement and making the product. And meanwhile, once we'd made what we felt was pretty good stuff (in trial 1), we'd started ordering our raw material so it would be in place by Feb 27. And now all these issues with [this requirement] - what were we going to do?

He went on to describe the teleconference discussion among the technical team members after receiving this customer feedback:

This is where it gets kind of interesting with all the different personalities. [The product development specialist], he's a technical guy, he likes playing around with technical stuff. He's saying, 'well, you could add this, you could add that....' You can always add something! Meanwhile, my background's manufacturing so my focus is—and also the timeframe we're on—'we don't want to start adding variables, we want to nail down as fast as we can.' So [in the team] we're trying to find the right balance.

Input from scientific members highlighted several alternatives. The team narrowed these down to two ingredients that might adjust the product as required. However, trial and error would be the only way to assess how much of these ingredients to include and how to incorporate them. The team was able to find a supplier for the first ingredient. The second ingredient was more unusual. The development engineer explained how he turned to his local colleagues for leads on this part of the problem.

This is where that spirit of the site came in. I was just talking to [X & Y] because I knew we used some [similar ingredients] somewhere on site. And [X] said, what're you doing? And I told him. And he said, 'well we're actually making some [of that] right now using some masterbatch - it's about what you'd need. I can have a barrel made and put off to the side.' Perfect, so we had our [second ingredient]! [This was] the result of happenstance talking to people and a helpful attitude.

The local production engineers and operators discussed among themselves, while “keeping an open enough mind,” how they might handle these additional ingredients if they were eventually required. A day before the deadline for the trial, the team's scientists came back with some experimental data, concluding that the first ingredient would help achieve the goal, but, on its own, would not get them far enough. Fortunately, as the development engineer explained, they were able to extrapolate from this feedback to judge that “if we had time, and if we added [ingredient 1] and added [ingredient 2] on top, we had a high chance of being where we needed to be.” He went on:

So when it came to this date, we had the pilot trial results because they'd got them together very quickly, the vendor came through with [ingredient 1] and the polymer plant had the time to run [ingredient 2]. When we ran, we said we had enough information to try them and, what d'you know? When we got the customer feedback a month later they said, 'this stuff is good!' ... So that's my happy story.

Having the support of and ready access to local colleagues and resources meant that the production team was able to meet their deadlines, incorporating both ingredients successfully during the trial.

In this episode, team members were made aware of the potential relevance of local resources and expertise for their problem because of their participation in activities and conversations in that local context. And, once identified, locally situated knowledge was easily appropriated for the team's purposes; as soon as the engineer's colleagues became aware of the purpose of the project, they were able to think of ways to resolve the issue and willing to assist him to do so. The knowledge these colleagues brought to bear on the problem was integral to activities in this particular site, and it would have been difficult for team members located elsewhere to have found it, much less integrated it into the team's project. Local insight and practical expertise were applied to the team's work in a timely

manner, despite a very tight schedule, illustrating an unintended benefit of the team's dispersion. Finally, the episode conveyed a sense of satisfaction and surprise experienced by members of the team in being able to achieve a successful outcome through an unexpected source of knowledge.

Episode 2: GROSSO "Something in the polymer." GROSSO was developing a product to meet an established set of end-use characteristics for a high-end market segment. To achieve the physical product properties the market required, the team experimented with new raw material components and specialized processing techniques. Following a disappointing production trial, the team had undertaken a series of experiments to eliminate possible sources of failure. These results also were unexpectedly poor. Explaining that they had verified the preparation of the material and the processing conditions, the experimental scientist commented that there was "something strange" about their polymer mixture:

The first trial here didn't work – the rationale was that we hadn't [prepared the mixture] sufficiently....
The second trial also didn't work – but we're 99% certain that the polymer was [prepared] enough.
There was recent note from [the Team Leader] explaining the rationale. We [checked our processing parameters against a model from one of the process modeling specialists]. With those settings we should have got [good properties].

Reasoning that the source of problems could be one or more unfamiliar components in the recipe, the team sought expert knowledge of the chemical behavior of these components. The scientists in the team thus turned to local specialists explaining that "we called you in based on your prior work on exploring the chemistry of [particular product compositions]". One scientist described the discoveries they had made so far:

We've explored obvious parameters such as [property1], [property2], the (theoretical) model itself.
That fits with many other situations so we don't think it's the model. So we need to start looking at polymer composition.

Then, through discussion with these specialists, the team was able to focus their attention on a single ingredient, and to test hypotheses about the underlying chemical processes. The team 'borrowed' the practical expertise of the advising experimental scientist who undertook experiments that week on behalf of the team, explaining:

I'm not in the project team. I got involved because the work needed to be done reasonably quickly....
there are a few other people who can use it (the equipment) besides me. My name probably came up because of the work I did for another project.

Elaborating on her role she commented that "the usefulness of the [local workgroup] is that you have easy access to resources and help on short notice... people are grouped randomly so to have a spread of skills available in each workgroup." The team leader confirmed this approach to local support—which his colleague apparently took for granted as the way things were done—saying, "workgroup members are considered flexible resources, primarily for experimental work. If they're at SiteW, they tend to be flexible resources anyway. A lot of those are available to everybody as resident experts." By drawing on both conceptual and practical expertise from local colleagues the team was able to advance its exploration of the root causes of its product performance issues.

Similar to Episode 1, this case shows members of a dispersed team in a good position to identify local sources of assistance as a result of historical experience with both people and equipment on site. Further, this locally situated knowledge—both conceptual and practical—was quickly and easily leveraged in support of the dispersed team's needs,

leading to an efficient outcome. In contrast to Episode 1, participants' attitudes about the exchange lacked the sense of surprise and unexpected pleasure that marked the other story. Instead, although not unappreciative, team members perceived the support of local colleagues as part of their job. At the same time, those colleagues also took it for granted that they should be available to support dispersed team needs. This positive social dynamic is likely to facilitate rapid and effective responses to dispersed project issues even when the team appears to be resource constrained.

Leveraging locally situated knowledge. These two cases illustrate the first form of using situated knowledge. In episodes in this category, dispersed teams were able to draw on skills, expertise, and capabilities that happened to be located *close* to where some team members were struggling with a specific problem. Twenty-one of the significant learning episodes identified in data analysis were categorized as leveraging locally situated knowledge (knowledge of both on-site team members and their local colleagues) in this way. Specifically, on-site team members' awareness of their colleagues' expertise, their own experience with physical and abstract resources in the immediate setting, and their understanding of local practices (or 'ways of doing things around here') enabled them to engage locally situated knowledge to benefit the team's project. Physical features of the immediate context often prompted on-site team members—already steeped in some social context—to undertake a particular useful avenue of thought or action.

By virtue of understanding local site norms of participation, on-site team members were also able to access support for accomplishing the team task. This ability allowed the rest of the dispersed team to draw on additional practical skills and physical resources from that particular site—thereby reaching beyond the expertise of official team members. As in these two episodes, 11 of the 21 episodes described a critical role played by local colleagues who were not formal team members. Next, we examine two cases illustrating the second form of accessing situated knowledge.

4.2 Two Episodes that Illustrate Teams Liberating Remotely Situated Knowledge

Episode 3: NERO "Scaling up to production." NERO was developing a well-specified product for a key customer. The team had already undertaken a series of successful pilot scale trials to verify the reproducibility and robustness of the design. Team members explained that the various facilities offered different capabilities and different opportunities for learning about the product. For example, the sales person commented, What we're trying to do with manufacturing is very different to what the [pilot plant] tries to do. Manufacturing are always trying to replicate, under very controlled conditions, the same product that you had last time, some very distinct recipe. The folks at SiteW are very often trying to do a spectrum of products which is indicative of the change in a given set of variables. ...It's quite an art to get a good representative set of samples from SiteW for a given variable.

He continued,

What we try to do is get onto the production machines as quickly as possible because, wonderful as the SiteW machine is, it's a pilot machine so it's very flexible but it's not very representative of all that actually happens in production. ... so we'll move onto the (production) line as quickly as possible, because it gives the operating team down there a chance to learn earlier about this process as well—because they've got certain things they can tune with their equipment.

The experimental scientist concurred on the dual implications of having flexible but small-scale equipment:

That's right, because although we are a pretty wide and variable unit at SiteW, obviously it is [for] real-life industry and we have struggled with the variations of the [intended application]. But once we had two or three very successful trials and we had repeatability and reproducibility, and [had product] accepted from the line here, we then scaled up to [the production line] at SiteH, which gives us the opportunity to produce it on a much larger scale.

At this point, confident in the design, the team turned to making the shift from pilot to full-scale production. The project leader emphasized the experiential nature of this learning process, due to a lack of quantifiable parameters:

There's always the question of scalability—scaling up from the pilot line to the plant line—,which is unpredictable at times... there's not a complete correlation between the pilot line and production line. [Learning is] just a matter of trial and error, we don't know of anything better. Normally [the parameter set] is at least close, though we might have to tweak it a bit on the production line.

Team members recognized that learning about the production process was inherently tied to the physical plant and equipment and that those understood the respective facilities could make good estimates in the absence of quantitative specifications. Thus when the first SiteH production trial was due, the experimental scientist from SiteW was asked to participate. The project leader explained that this scientist's presence at the first production trial was valuable "because he had the experience of knowing what the product's supposed to look like and partly because he'd never been here, we didn't even know who he was!" His ability to interpret product appearance was critical because its aesthetic properties could not be quantified but were important to customers. The leader elaborated, "we wanted to meet him, wanted him to meet the folks here, so he could develop those networks, have folks know who he is." Since the team was under less time pressure than some other teams, they had been able to take the time to arrange this. Describing the January trial as a "major event", the scientist talked positively about what this entailed for the team's learning and for the project's advancement:

When we got the chance to meet in January we could talk in a lot more depth and show each other samples and ways of working. And I got to know and see how [the team leader] works over there and, although I'm not in my own environment, he obviously saw how I worked and interacted with other people while I was over there at the plant in SiteH. So I think it's a big bonus for the project. Certainly (the trial in) January was a major event and helped the project along.

In this episode, dispersed team members were highly cognizant of the situated nature of processing knowledge. This awareness may be due to a strong association with concrete equipment and facilities. Contrary to the first two episodes, however, because relevant experience was spread across geographically separated sites, it was less easy for NERO to rapidly appropriate that knowledge and experience. The team tackled the situation by having the scientist move to the location of future production. Here, he could observe and experience the production process directly and was better positioned to identify differences and similarities with what he already knew. By engaging directly with local engineers and operators with insight into the unique capabilities of the production line, local knowledge and experience was utilized, and all participants to the trial gained a better understanding of the process and each other, leading to a successful outcome.

Episode 4: BIANCO "Clarifying the commercial opportunity." The BIANCO team was developing a new product for a new Japanese customer in a highly strategic market

sector. The product was to be incorporated into a major product innovation by the customer, and the team sought to understand the customer's market strategy to estimate the current opportunity and the longer-term commitment required of DevCo. The global market manager, based at SiteB in the US, explained that team members not in regular contact with the customer became concerned because this strategy information was not forthcoming:

For instance, we wanted our Japan commercial colleagues to engage in discussion with the customer commercial to understand what's the strategy, what's the intent? Because they (the customer) were trying to break into a new market in which they weren't yet a top player, in which the technology is rapidly changing, with very long lead times for getting new products to the market place. So our question was: 'what's going to make you, Mr. Customer, be successful?' ...Like anything, there's a level of risk, so we need to do our own assessment of: do we think they're going to be winners from the technology standpoint, because they offer performance benefits that others don't...? And we weren't getting that perspective.

She added that one of her Japanese colleagues also expressed frustration that she wasn't supporting the program because she kept pushing to learn about the customer's strategy and marketing plans:

That's my job. Because that's the commercial risk. You know, we can make a super product but if the customer can't sell then we've invested a lot of effort and resources into something that's not going to pay off. And this was just highlighted because they aren't leaders in the market they're trying to get into, the technology's changing fast, and their current distribution system [is not appropriate]. ... So I was really focused and pushing that, and they viewed as me being not supportive and behind the program. And I thought I was just trying to do the right job and push the issue of what the risk factor is here. For the bang for the buck, are we happy with the level of risk we're assuming?

Her European technical colleague concurred with this interpretation, remarking that they had "gone through some fairly challenging periods around nailing down exactly what we're doing here in terms of technical requirements for the product and specifically what the commercial targets of [the customer] are. And that has clearly led to some pretty difficult discussions in-house."

A breakthrough occurred when remote team members realized that the customer itself had not thought through its strategy to the degree desired and so had not yet formally identified internal people responsible for defining sales, marketing, and distribution plans. Despite excellent technical relationships, the team's liaison person could gain no leverage in the customer's commercial organization until there were contacts in place. The market manager described this "ah-ha" experience:

I think, we in the US were frustrated with our Japan commercial colleagues not providing the information that we wanted. And it was an ah-ha for us when we realized that they truly don't have the right people in [the customer]. It was kind of through no fault of our colleagues. But we were getting frustrated with that, thinking our colleagues weren't putting priority and effort into it. When actually there was a void with the customer being able to articulate that themselves.... I think the ah-ha was that it wasn't that our commercial colleagues weren't trying. There was a genuine gap in that the customer hadn't thought out that strategy well. So we were getting frustrated thinking that, internally, we weren't doing something, and in fact there was an external gap which we have less control over.

The SiteW-based research scientist agreed. "That was probably one of the biggest issues because the customer themselves, for the longest time, didn't have their own strategy clear and we didn't know it." He elaborated,

I think, throughout the development, there have been some challenges for us in terms of trying to reach that clarity. I think, in part, due to the fact that our customers themselves were not entirely sure what they were going after. And with them having a degree of uncertainty, they were not feeling that comfortable to discuss it with us. That has got better.

Because the customer was new to DevCo, the team had little prior knowledge to fall back on in understanding the way that customer responded or what were its key priorities. This required a delicate balance between pushing for information and not destroying a newly developing relationship.

...And while we've obviously aimed to keep the relationship very good with [the customer], we've obviously had to make them aware that we have a degree of uncertainty around what their market targets are. I believe we've done that always in a very positive way but we've certainly had to ask them to be clearer in defining what their target market is.

Greater understanding had come when more members of the team, together with additional senior DevCo representatives, had been able to meet customer representatives in person—first in Japan then in the US—to discuss the need for information and to address the relationship more broadly. The research scientist explained:

We had a frank discussion and probed them on points such as: 'Well, by the time you launch your product, the technology in the market place could be so advanced that it makes some of the advantages you're claiming you're going to bring to the table not true benefits. And all these other companies are [already] in there today. So one, you're the newcomer, and two, you're bringing something that may be a me-too. So how are you going to be successful?' So we had that kind of frank discussion with the customer, which made them a little uncomfortable, but it's one that in true spirit needs to happen. We're trying to help them think about their market and their approach, their timeline and the product. We are very confident of our ability to manufacture this new product design and be able to supply that. But we think we may not get the benefits, i.e. the volume of the sales, because the biggest risk is the customer's ability to put that product in the market place.

Although the commercial opportunity still was not defined completely, these events had positioned the team to make a more informed decision on whether to proceed on the project.

Episode 4 also reveals knowledge being remotely situated from where it is needed. In this case, the US commercial team members assumed that the information they wanted was known somewhere. They were largely unaware of the intricacies of the customer relationship that their local Japanese colleagues were dealing with. Their ability to learn from this situation was hampered initially because they did not recognize this real gap in the team's knowledge. It was a frustrating period for team members because they felt they were missing information but could not pinpoint the gap. As in Episode 3, a physical meeting—this time involving otherwise remote team members as well as their customer counterparts—served as a trigger for establishing an enhanced base of common knowledge that allowed the team to move forward. In this episode, BIANCO has not yet resolved the issue but was confident that the team had identified the important elements.

Liberating remotely situated knowledge. These two cases illustrate the second form of using situated knowledge to accomplish team goals. Episodes in this category showed dispersed teams as able to draw on knowledge, skills, and capabilities located *at a distance* from where certain team members were struggling with a problem. Here, situated knowledge eventually played a vital role in the dispersed team's problem resolution. Of the 44 significant learning episodes, we coded 32 as involving knowledge initially situated remotely from where it was finally engaged or applied³. In 18 of these episodes, team members recognized quickly that relevant resources or expertise were located elsewhere

³ Some episodes included both patterns of learning so the numbers do not add up to 44.

from where they might be useful, and on ten of these occasions—as in Episode 3—team members took deliberate steps to relocate people and/or materials.

The remaining 14 episodes described situations where relevant situated knowledge was not immediately apparent to anyone on the distributed team. Because their own situated knowledge (for example, about work practices, perspectives, or available resources) was taken for granted by local members—and at the same time was not visible to remote members—it tended not to be discussed explicitly (see also Cramton, 2001). Specifically, knowledge of local practices and competencies often allowed team members to respond to team-level issues without making this taken-for-granted local knowledge apparent to their remote (or dispersed) team colleagues. Under these circumstances, the rest of the dispersed team tended not to recognize the locale-specific nature of certain members' knowledge until gaps were made salient through communication difficulties arising when dispersed members needed to interact more closely on an issue. Such gaps in understanding catalyzed a process of uncovering the source of confusion. However, in 10 of the 32 cases, as in Episode 4, dispersed team members did not even realize there were (still) important gaps in their understanding until they had subsequent opportunities to confront a different setting or context.

5 DISCUSSION

These four episodes convey nuances and complexities associated with the use of situated knowledge by dispersed teams. These stories—and the set of 44 from which they were taken—suggest that boundaries between organizational sites can limit knowledge sharing, just as boundaries between functions (Dougherty, 1992) or occupations (Bechky, 1999) have been shown to do. Shared practices, perspectives, and repertoires of resources tended to exist in these organizational sites, and team members who worked there were aware of and could access them. Knowledge situated remotely from where it was needed was less easily identified or leveraged, due to lack of awareness on the part of those facing the need. At the same time, the stories suggest that situated knowledge can be a valuable resource for problem solving in dispersed teams, and highlight strategies for how to access and de-contextualize (or liberate) remotely situated knowledge in a way that it become useable by the broader project. The data also suggested critical factors involved in ‘liberating’ situated knowledge and putting it to use.

5.1 The Value of Situated Knowledge for Dispersed Development Teams.

First, situated knowledge played a valuable role in all teams studied, with implications for both efficiency and effectiveness in accomplishing collaborative work across multiple sites. For example, the BIANCO project team gained timely access to a vital new ingredient, through knowledge of specialists and capabilities situated in one team member's site. Similarly, GROSSO gained timely, tailored guidance on how to improve their product's performance, through members' awareness that related issues had been explored in that site before. In NERO, the experimental scientist was able to contribute valuable suggestions and observations once he was physically present at the first production trial. Although the team had to make an effort to get him there, his expertise developed on the pilot line proved effective while working closely with other team members in the real

production setting. Finally, in Episode 4, BIANCO team members did not obtain access to necessary contacts and information in a timely manner at first, but ultimately direct contact between key representatives of the team *and* their customer was effective in improving the team's comprehension of the customer's strategy. Overall, the data highlighted the prevalence of situated knowledge as a critical element in accomplishing dispersed collaborative work. However, leveraging the value of this knowledge first required awareness of it as a resource, as explored below.

5.2 Critical Factors in Learning from Situated Knowledge

Visibility. The data suggested that awareness of situated knowledge varies in ways that can be problematic to its use. Specifically, situated knowledge can be invisible to 'non-natives' (those not based at a given site) because they lack exposure to it. At the same time, site 'natives' can take their knowledge for granted, making it effectively invisible to them too, unless their awareness is catalyzed by a need or event. Dispersed teams varied in the manner and degree to which they were aware, or became aware, of the existence of site-specific expertise, resources, or other capabilities that might be relevant to their current task challenges.

When dispersed members faced an issue locally, their own knowledge—situated in both proximal and historical interactions with people, practices and resources—often triggered fortuitous awareness of useful inputs to dispersed team learning. For instance, in Episodes 1 and 2, team members, prompted by prior knowledge of practices in the local setting and by what they knew of their colleagues' domains of expertise and activities, turned to particular local colleagues for advice and support. Casual conversation with on-site colleagues triggered the BIANCO engineer's identification of suitable expertise to address his team's ingredient problem. GROSSO team members' historical knowledge that colleagues had previously worked on a related project prompted them to turn to these colleagues in solving a product composition problem. Shared history was similarly instrumental in identifying a technician, recently transferred to R&D, to assist with BIANCO's testing requirements. As the technician explained, "When [the team leader] found out I was here, he just grabbed me because he knew I had [previously] been a [specialized] technician in the plant."

As others have noted (e.g. Allen, 1977; Salancik & Pfeffer, 1977), proximate colleagues talk frequently and informally among themselves, creating opportunities to pick up and record stray facts about others' experience and expertise that might be useful at a later date. Thus, when members of a dispersed team seek direction or skills to resolve a problem, local members can turn to on-site colleagues—both 'recognized experts' and other colleagues who are simply accessible—for advice, feedback, and practical assistance (see also Sole & Edmondson, 2001). In new product development teams, because expertise is a critical resource, knowing *where* expertise is located is an essential part of being able to coordinate skill and knowledge dependencies effectively (Faraj & Sproull, 2000). Both laboratory studies (Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000) and field studies (Austin, 2000) show that a well-developed transactive memory system improves group performance. The present study suggests that team members' knowledge of where expertise is located in their local organizations, (i.e., transactive memory in local

organizations (Wegner, 1987)), can complement the transactive memory of the dispersed team and thus play a part in the team's learning process.

In addition to having locale-based transactive memory, dispersed team members possess knowledge situated in ways of working and in the use of particular resources (equipment, tools, space, language, or conceptual models) at their particular site. Frequent and historical exposure to these resources and work practices similarly triggers useful avenues of learning by dispersed teams. For instance, as a result of sharing pilot production facilities at SiteW, local GROSSO team members learned of the existence of a particular piece of equipment that was, until then, used primarily in processing products for a different business. Recognizing that their intended product characteristics were similar to those of the other product, they foresaw the potential of using this item to create better processing conditions for their own product. After this equipment was successfully used in local trials, the team eventually specified this design for the production line where GROSSO product would ultimately be manufactured.

By drawing on knowledge of locally available equipment and historical work experience, GRIGIO also made a breakthrough in selecting a novel production technique to manufacture their product. The team had repeatedly experimented with increasingly suitable but also increasingly expensive ingredients, in efforts to achieve targeted product characteristics. Their need to simultaneously address issues of product cost, safety and manufacturability eventually prompted them to consider other production lines at the designated manufacturing site. Considering these other assets opened up the opportunity to use a different processing technique that could accommodate the manufacturability issues associated with the preferred ingredients.

Whereas proximity to or a shared history of people, resources and practices made it easy for team members to identify useful inputs to learning *within* their site boundaries, the absence of proximity and common history hindered the identification of useful learning inputs from *outside* these boundaries. This was manifest in the difficulties experienced by BIANCO in Episode 4. The newness of the relationship meant that BIANCO members had no pre-existing knowledge of 'who-knows-what' in the customer's organization, and little recourse to other sources when their sole (technical) contacts were not forthcoming with the desired leads. Moreover, US and Japanese team members were not yet familiar with each group's respective practices and social networks. Therefore, the US members could not easily discern that, despite having close technical relationships with customer representatives, their Japanese colleagues had not yet established suitable commercial contacts. Austin (2000), studying collocated, cross-functional teams, proposes that *situated expertise*—a combination of transactive memory and shared awareness of each group member's social ties—is likely to be strongly related to group performance. Episode 4 suggests, however, that although dispersed team members may be aware of remote members' domains of expertise, it is more difficult for them to find out about remote colleagues' social ties. Hence, the development of robust *situated expertise* in dispersed teams may be limited.

When concrete resources such as equipment and materials played an important and necessary role in activities, the situated nature of those activities became more visible, and inclined people to think more consciously about *where* they should learn from and about those activities. Both Episodes 3 and 4 describe situations in which relevant knowledge was

remote from where it was needed by the team. In Episode 3, NERO members took steps that enabled them to re-situate relevant-but-remote sources of knowledge, to overcome hurdles presented by being geographically dispersed.

Appropriability. Once knowledge is identified as relevant, the question arises of how easily and effectively it can be applied to address a dispersed team's learning needs. When knowledge was locally, rather than remotely, situated at the site in which dispersed team members faced a specific problem, the speed and ease of utilizing that knowledge was far greater than when it was not local. The surrounding practices and context of the site facilitated its effective engagement.

First, as members of site-based communities, members of dispersed teams were able to request assistance and be taken seriously (cf. Wenger, 1998). Local colleagues seemed to be receptive to requests for assistance, when they could associate the task with the overall endeavor of the site and if the request was made according to site-specific norms of participation.

Second, local colleagues were already familiar with the physical environment and facilities and were able to step into roles and act effectively with little set-up time. In this way, ad hoc participants were able to contribute to the team's work. In Episode 1, local polymer plant colleagues were willing and immediately able to invest time and effort into meeting BIANCO's need for an unusual ingredient. They understood the time pressures and were in the habit of "helping out". At SiteH, which "operates with networks," it was accepted practice to informally involve whomever had appropriate expertise to help a project in need. In the other example described above, the testing technician at SiteH was quite amenable to be "grabbed" by the project leader to provide trial support. In Episode 2, GROSSO was also able to get timely feedback from "resident experts" on product composition and, almost immediately following that meeting, the assisting experimental scientist started work on the tests the team required. Episode 2 conveyed the notion of the support role that was an acknowledged though unwritten part of the job description for each member of the broad development organization at SiteW.

Third, team members themselves were able to act promptly on their own locally situated knowledge because they were well versed in the local context. They knew where to look for appropriate resources, and could draw on their knowledge of the setting and practices to accomplish their objective efficiently. For example, once GRIGIO had identified a substitute production technique and line to make its product, the production representatives on the team were able to quickly locate and recommission old equipment, and run a qualification trial. This was possible, the process technician explained, because both he and the manufacturing lead on the project had extensive experience working with the electrical controls of that general class of equipment and with both production lines. In another episode, when BIANCO was under pressure to produce samples for its client, team members were able to leverage local knowledge of how the production line scheduling system *really* worked:

For a short period there we were in danger of missing our program deadlines. We were being told, 'Can't do it, other things happening on the plant, you'll have to wait.' ... Our project was in [the system], we were following the process. The first question asked when you have a conflict is, 'Is it in the system?' We say, yes. They say, 'Oh, but we can't do it anyway because there're too many orders.' ... our trial scheduling still comes down to negotiation and communication - you've got to communicate with the scheduler or it does not happen. You can do [the system route] till you're blue in

the face; that makes sure that you've got a chance. But unless you talk to the scheduler and the person on the line, make sure they understand and agree, then it's not going to happen. So there's the official process and the unofficial process.

In contrast, when relevant knowledge was situated remotely from where it was needed by the dispersed team, it was more difficult for team members to learn from and build on that knowledge. Each dispersed team member's work practices and approaches to problems were strongly influenced by physical and social resources at hand—practices and approaches that did not transfer easily from site to site.

First, the social context differed from site to site. For example, although sharing the same broad functional structure, the correspondence among roles, responsibilities, and expertise tended to differ from site to site. An individual's local experience therefore did not necessarily help identify remote experts. Similarly, sites varied in terms of physical facilities, repertoire of potential production techniques, and ability to undertake particular experiments and evaluations. The specific availability of resources shaped individuals' preferred approaches to solving problems. As NERO's project leader commented,

Some folks might favor the use of [one technique]. Some might focus more on [a different technique]. There're probably twenty ways to solve most problems. There's that flexibility there; there's no right answer. Often we don't know what's the best - we just know the one we can come up with.

Unless a team member was familiar with a remote context, it was difficult to effectively apply his or her own situated knowledge in that context.

The significant learning episodes suggested that dispersed teams benefited from remotely situated knowledge when they were able to 'liberate' it from its original context, to apply it in a new context. One strategy that seemed effective involved moving key people physically, if not for the duration of the project, at least for a period—as occurred in Episode 3—which allowed them to contribute directly to particular activities or events. This movement of people had the unintended positive effect of creating an opportunity for knowledge sharing beyond the current work; it often led to the development of a shared history with other members of the team and with the extended team context (i.e. the multi-site context).

In a number of episodes, remotely situated knowledge was only made visible and liberated for use by the inadvertent—rather than intentional—movement of people. Prior to this physical relocation of key people, dispersed team members often did not recognize their team had a 'knowledge gap.' For example, in Episode 4, it was initially difficult for remote BIANCO members to recognize that their apparently straightforward request for commercial information hinged upon aspects of the prior negotiation of nuances of the new business relationship. Once a formal meeting with the customer had taken place, however, it was possible to acquire the needed information. In a similar chance occasion during a non-routine visit to their customer, GRIGIO scientists learned of other potential suppliers of new ingredients that subsequently enabled them to advance their product design significantly.

Movement of key people was not the only effective strategy for engaging remotely situated knowledge. The data also suggested that the movement of materials or the transfer of structured electronic data were occasionally sufficient. However, the prevalence of this strategy in the learning episodes selected by team members suggests that, for those

involved in dispersed teamwork, relocation can be a highly influential and satisfying factor in dispersed team learning.

5.3 Contributions to the Literature

Geographically dispersed, cross-functional teams face a number of obvious hurdles to collaborative work, such as different educational backgrounds and different time zones. Our study suggests that such teams must also deal with another, more subtle, barrier—that of critical knowledge being situated in team members' local contexts. By describing the concept of situated knowledge and characterizing its role in dispersed team learning, this study contributes to greater understanding of what dispersed collaboration entails.

Further, our study supports the argument that geographically dispersed, cross-functional teams can be an effective tool for accomplishing challenging development goals, but demonstrates that this is possible for reasons other than those previously offered. Specifically, dispersed teams may be successful, not only because they include an appropriate mix of specialists in the team itself (Townsend, DeMarie, & Hendrickson, 1998), but because they have enhanced access to a greater breadth of situated knowledge from which they are also better positioned to learn. Without having individual members who simultaneously participate in site-based communities and practices, a team would not have the same level of access to resources and capabilities in that site. In fact, it is likely that such teams would remain oblivious to key sources of learning available in that site.

Finally, although team members in one site may be able to engage critical local knowledge on behalf of a member elsewhere, this is unlikely to occur if the team members cannot adequately perceive the needs of remote colleagues. Our observation that occasional relocation (or co-location) can minimize such occurrences echoes earlier research on both learning (e.g. Tyre & von Hippel, 1997) and virtual teamwork (e.g. Maznevski & Chudoba, 2000). Our emphasis on practice shows that physical presence stimulates problem-solving through enabling social interaction with people immersed in different practices and perspectives, as well as through confrontation with the physical particulars of the setting (Tyre & von Hippel, 1997).

5.4 Implications for Practice

The findings from this study suggest that organizations might benefit from developing a series of complementary knowledge management approaches that specifically acknowledge the context of practice, and promote possibilities for interactions within and across these contexts. Examples of managerial policies that might promote coherent site communities and practices include support—and sufficient 'organizational slack'—for broad, informal interaction on site, encouragement of a culture of generalized knowledge sharing, and recognition of supportive behavior in this regard. These organizational characteristics are likely to facilitate the discovery of efficient channels of learning, as well as develop the community memory of available resources and past experience. Although some sources for learning—such as individual domains of expertise—may well be electronic documented for automated search and retrieval later, most sources of situated knowledge identified as useful are not of a form that can be easily categorized and codified.

Stories that record historical site experiences may be a better way to capture and retain historical situated knowledge.

Managerial policies to promote cohesion between site communities and different site practices might include support for periodic inter-site movement of key people who might act as ‘bridges’ of firsthand experience to aid the interpretation and elicitation of practice-based knowledge from other site contexts. Again, although electronic indices can be used to identify remote experts and other resources, if remote colleagues can engage these with an understanding of local practices and values, their learning is likely to be more effective.

6 CONCLUSIONS

Researchers have called for more research into the processes of how knowledge is created and shared (Argote, 1999; Argote & Ingram, 2000). The research reported here focuses on the role of situated knowledge in knowledge creation and deployment in dispersed development teams. Our findings regarding dispersed team learning patterns show that knowledge boundaries come in multiple forms. In addition to notions of functional and occupational knowledge boundaries identified previously, site boundaries also play a role in how easily knowledge is diffused and applied. The concept of situated knowledge associated with local work practices is offered as a useful refinement to understanding how knowledge flows across site boundaries in organizations.

This research adds to the existing theory on knowledge management by identifying a number of characteristics that describe the effects of situated knowledge on team learning. It also improves our understanding of learning in dispersed teams by illuminating some of the interpersonal practices through which such knowledge is leveraged.

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