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Abstract

Organizing depends on the integration of specialized knowledge that lies distributed across individuals. There are benefits from specialization, and, yet, the integration of knowledge across boundaries is critical for organizational vitality. How do organizations benefit from knowledge that lies in different domains without having to transfer knowledge? This paper describes results of two exploratory ethnographic studies of knowledge integration in industrial research organizations. It introduces a knowledge integration mechanism - 'thinking along' – that has not received much attention by researchers before. Thinking along is a mechanism that allows for knowledge integration without the need for transfer. As a consequence, benefits of specialization obtain even as knowledge from one domain informs knowledge from another. The paper describes how researchers use thinking along to integrate knowledge within and across boundaries. It concludes with implications for knowledge management and future research.

KEY WORDS: distributed knowledge; industrial research; knowledge integration; knowledge transfer; thinking along

A central claim of the knowledge based view (KBV) of the firm is that organizational capabilities depend not only on specialized knowledge held by individuals but also on an organization's ability to integrate that specialized knowledge (Galunic and Rodan, 1998; Garud and Nayyar, 1994; Grant, 1996a; 1996b; Huang and Newell, 2003; Kogut and Zander, 1992; 1996; Okhuyzen and Eisenhardt, 2002; Purvis et al., 2001; Spender, 1996). Characteristics of learning processes are such that organization members have to specialize in order to acquire a high level of expertise. Given the enormous amount of relevant knowledge available in many fields and the limitations of human information processing (Simon, 1991), individuals have to focus. Moreover, due to the situatedness of learning, organization members are only able to gain expertise with regard to practices that they are actively engaged in (Lave and Wenger, 1991; Tsoukas, 1996). Finally, learning processes are characterized by an increasing rate of return: learning in a domain proceeds faster when someone has already more knowledge in that domain, thus favoring specialization (Levinthal and March, 1993). It is through the specialization and differentiation of the learning processes of its members, that an organization is able to get both the range and the quality of expertise that is required for complex production and innovation processes (Wegner, 1987).

At the same time, the specialization of organization members turns organizations into distributed knowledge systems in which the range of knowledge that is required for production or innovation is dispersed over organization members (Tsoukas, 1996). As a consequence, organization members have to integrate dispersed bits of specialized knowledge held by individuals, i.e., to apply this dispersed knowledge in a coordinated way (Becker, 2001; Demsetz, 1991; Grant, 1996a). The KBV thus extends existing

theory on organizational differentiation and integration (e.g., Lawrence and Lorsch, 1967) to include the differentiation and integration of knowledge.

The knowledge integration mechanism that is most widely advocated in the literature is knowledge transfer (e.g. van der Bij et al., 2003; Cabrera and Cabrera, 2002; Hansen, 1999; Szulanski, 1996). By transferring knowledge to someone who is able to may use it in his/her work practices and is able to combine it with his/her personal knowledge, pieces of knowledge can be integrated. In this way, knowledge transfer enables the re-combination of knowledge that is associated with innovation (Galunic and Rodan, 1998), the integration and re-use of best practices at several places in an organization (Argote, 1999; Szulanski, 1996) and it may turn individual learning into organizational learning (Andrews and Delahaye, 2000; Huber, 1991; Nonaka, 1994). Indeed, most knowledge management activities are oriented towards the improvement of knowledge transfer (e.g. Hansen et al., 1999).

However, recent work in the knowledge-based view of the firm has stressed the downside of knowledge transfer: it is costly and counters the necessary specialization of organization members. It has frequently been observed that the transfer of tacit knowledge is difficult and requires prolonged close interaction (Collins, 1974; Kogut and Zander, 1992). Moreover, Brown and Duguid (1991) have argued that knowledge is situated within the practices in which it is applied. This makes the transfer of knowledge across the boundaries of practices and communities difficult (Brown and Duguid, 2001; Carlile, 2002). Finally, the transfer of knowledge counters the specialization that is required for the effective acquisition of knowledge (Demsetz, 1991, p. 172). Grant (2001, p. 147) states that ‘any system of production that requires each individual to learn what

every other individual knows is inherently inefficient'. Therefore, a central question is how organization members realize knowledge integration while maintaining the benefits of knowledge differentiation.

Part of the answer lies in other mechanisms that have been distinguished. Next to knowledge transfer, Grant (1996a; 1996b; 1997; 2001) distinguishes three other knowledge integration mechanisms: (a) rules and directives; (b) sequencing and routines; and (c) group problem solving. According to Demsetz (1991) and Grant (1996b), rules and directives, and sequencing and routines are able to integrate knowledge while maintaining specialization and economizing on knowledge transfer. However, these mechanisms seem to be limited in their flexibility. Moreover, the overview of knowledge integration mechanisms presented by Grant is not empirically grounded or tested, but based upon earlier task integration mechanisms (e.g. Galbraith, 1973; Lawrence and Lorsch, 1967; van de Ven et al., 1976). In short, knowledge integration is in need of further exploration (de Boer et al., 1999; Grant, 1996a; Huang and Newell, 2003).

How is it possible to integrate knowledge without having to transfer it? We address this question through observations from two field studies of industrial research groups in which we explored knowledge integration. In conducting our study, we adopted a dynamic perspective on knowledge integration. Okhuyzen and Eisenhardt (2002) and Swan (2003) criticize existing studies for having a predominantly static view, in which integrating pieces of knowledge is like connecting pieces of a jigsaw puzzle or building with Lego blocks. This view neglects that knowledge integration concerns the application of knowledge, which is an active process. The process of integrating knowledge, does not only involve knowledge, but also knowing (Cook and Brown, 1999) and cognition

(Garud and Porac, 1999, p. xv). The integration of knowledge can also be interpreted as the distribution and integration of cognitive work (Hutchins, 1995; Weick and Roberts, 1993).

Our results contribute to the existing literature in several ways. First, we introduce the concept of 'thinking along', referring to temporary cognitive work with regard to a problem of someone else. Thinking along is an under explored mechanism that enables the integration of knowledge without the need to transfer. Second, we show different ways in which thinking along contributes to the practices of industrial researchers. Third, we describe the use of thinking along as a flexible knowledge integration mechanism, both within and across boundaries. Thinking along as a mechanism for knowledge integration has important implications for knowledge management as well. We will reflect on these implications in the final section of this paper. In the next section we will proceed by presenting the empirical studies and the methodology employed within these studies.

RESEARCH APPROACH

The empirical research on which this paper is based consisted of ethnographic studies in two industrial research groups conducted by one of the authors. We choose to focus on research organizations of industrial firms, because knowledge processes are a crucial part of the work of industrial researchers. We choose an ethnographic research strategy – which is based on interviews with community members and observation of their work practices in their natural context - for the following reasons. First, an under explored topic like knowledge integration calls for inductive, exploratory studies, grounding

findings in close observation of the phenomena of study. Relying on interviews as the only source of data would be too limited, since subjects are not completely transparent to themselves (Giddens, 1984). Second, an ethnographic study enabled us to meet the objective to study knowledge integration as it is actively realized in work practices, and not as a static structural feature. As Okhuyzen and Eisenhardt (2002) remind us, knowledge processes are ultimately about micro-social interactions among individuals. Finally, cognitive anthropologists and sociologists of science have shown that knowledge and knowledge processes are situated within a context of work practices, social relations and technical artifacts (Hutchins, 1995; Lave and Wenger, 1991; Lynch, 1985). Therefore, to understand the intricacies of knowledge integration we have to study it in its natural context.

The first field study was executed in the Group Buijs of Royal Philips Electronics. The Group Buijs is part of the NatLab, with 1700 researchers the largest of Philips Research Laboratories and one of the largest industrial research laboratories in the world. From its inception the NatLab has been located in Eindhoven (the Netherlands), the birthplace of Philips. At the time of study the Group Buijs consisted of about 25 researchers. Two third of them were research scientists, holding a PhD in physics or a related field. One third of the group members were research engineers with a higher technical or laboratory-oriented education. One of the research scientists and two of the research engineers were women, the others men. Their activities were divided into six clusters: ‘solid mechanics and tribology’, ‘plastic processing’, ‘thermal management’, ‘coating’, ‘printing’ and ‘home care’.

To increase the scope and variety of observations, a second field study was executed at Oil and Gas Innovation Research (OGIR). OGIR is a business group within Shell Global Solutions International and is located in Amsterdam (the Netherlands). Shell Global Solutions is part of the Royal Dutch / Shell Group. Although the general public regards Shell as an oil company, it says of itself that it is 'primarily in the energy business'. This is exemplified by Shell's growing focus on renewable sources of energy. OGIR describes its mission as contributing to sustainable development in the areas of energy and mobility by generating innovative technological options. This group had about 30 members, with a comparable composition as the Group Buijs.

Both research groups were engaged in quite fundamental research, exemplified by the fact that their researchers regularly publish in scientific and technical journals. Their primary objective is to deliver new technological options, which may be further developed by other groups. In the Group Buijs and OGIR, work is divided into projects, staffed by one or a few researchers. These projects are often part of larger projects. Business divisions pay most of the projects directly or indirectly, but some projects are paid from a company budget for fundamental research.

-- Table 1 here --

Our field studies can be classified as passive participant observation (Spradley, 1980). The highly specialized nature of the work of the groups made active participation impossible. One of us shared a room with some of the researchers, followed them in meetings and in their laboratories, had coffee breaks and lunch with them and joined other social gatherings. Our field studies started with introductory interviews with most group members. These interviews served as a source of factual information, but also as a

first occasion to build mutual trust, to negotiate access and to decide which researchers to follow more intensively.

In order to facilitate access to interactions and to make interactions more comprehensible, we chose to focus on the interactions of a few researchers. Six researchers were asked and agreed to be shadowed for several days. Part of the interactions during these days was tape-recorded. This was not done for those meetings in which asking for permission would be too disruptive, like in spontaneous encounters at the corridor. Notes were taken of those meetings that were not tape-recorded. Furthermore, before and after interactions the shadowed persons were asked for clarification on the meaning that these interactions had for them. In many cases we also spoke with their interlocutors afterwards, in order to learn their point of view as well. A number of the tape-recorded interactions were discussed sentence-by-sentence with the researchers, by reading the transcript together and / or listening to the tape together. We asked questions like 'Why do you say that?' and 'What do you think of that answer?' These discussions proved to be important to understand what was happening in interactions.

In total, more than 250 interactions were observed or documented and labeled with a number (e.g., E26; see Table 1 for characteristics of the field studies). The observed interactions comprised group meetings, cluster meetings, project meetings, research colloquia, appointments between individual researchers, lunches, coffee breaks and informal meetings at the corridor. In addition to face-to-face meetings a few written exchanges and telephone conversations were analyzed. We studied only research-related interactions between researchers. Interactions with development, marketing, product

divisions and allied organizations were left out of this study, because communication with other functional areas plays a less important role for fundamental researchers (Allen et al., 1980).

Field notes and transcripts of interactions and interviews were analyzed in line with the grounded theory approach (Glaser and Strauss, 1967; Glaser, 1978; Strauss and Corbin, 1990). This approach consists of a set of procedures to construct theory out of empirical data in an inductive and systematic way. These procedures focus on comparing and coding episodes, finding relationships between these codes and elaborating codes and relationships until they are saturated. After these qualitative analyses, all interactions from OGIR that were described in sufficient detail as well as a comparable amount of interactions from the Group Buijs were coded for an additional quantitative analysis (see Table 1). At the end of the field studies, preliminary findings were presented to both research groups. These member checks did not necessitate major revisions.

The field studies showed a variety of communication patterns and knowledge integration mechanisms. The knowledge integration mechanisms identified by Grant (1996b), such as routinization and group problem solving, were indeed found. This paper focuses on one particular knowledge integration mechanism that we identified - baptized 'thinking along' – which was not yet identified in the literature. Nevertheless, thinking along was a prominent mechanism used by researchers from both research groups. Moreover, the identification of this mechanism has profound implications for theorizing on knowledge processes and communication in organizations.

THINKING ALONG

Consider the following interaction. In episode E69, Luke comes to Jason, a colleague within the Group Buijs. Luke tells Jason that he wants to use an infrared camera to gain images of the heat distribution in an optical disc. This camera needs a filter to measure at a particular depth. Luke had used the camera before to measure the heat distribution in glass, but he wants to employ it for the measurement of polycarbonate now. This requires a different filter. He has purchased a filter but got distorted pictures. He wondered whether the noise in the pictures was caused by characteristics of the filter. The supplier yielded a graph of the characteristics of the filter. *"It is possible to draw conclusions from such a graph, but I lack the expertise to do so"* says Luke. Therefore, he goes to Jason, who works at the same corridor. Jason is an expert in optics and optical filters. Luke shows Jason the graph and asks: *"If you look at that, do you belief that the filter has a reasonable performance? Do you think that it has enough layers?"* Using his knowledge of optics in general and filters in particular, Jason concludes that the filter seems to be of sufficient quality. For Luke this is a reason to belief that his unsatisfactory results were not caused by a bad filter: *"Now I am pretty sure that I am not fooled by the supplier"*.

In this episode, Jason offers an answer that was new to him. Jason did not know in advance about the filter that Luke wanted to use, let alone have an opinion about the quality of the filter. His evaluation was developed during the interaction. This characteristic sets this episode apart from communications in which existing information or knowledge is transferred – for example when research results are presented to a larger audience or when a new researcher is instructed on how to use a piece of laboratory equipment. Furthermore, the new answer was developed with regard to a problem of

somebody else. Jason and Luke were not engaged in collaborative problem solving with regard to a shared problem. The episode consists of temporary cognitive work with regard to somebody else's problem. Therefore we called this type of interaction 'thinking along with somebody'. Thinking along is quite common in industrial research. Out of 109 episodes analyzed quantitatively, 36 could be fully or partly characterized as thinking along.

Thinking along was found within different situations. In the above example, two persons are interacting face-to-face: one person having a problem and another person helping on that problem. Luke, who was facing a problem, initiated this interaction. Other instances of thinking along were found in which a coincidental meeting was used to think along, for example when meeting each other over lunch, at the corridor or in the margins of a research seminar. An example of the latter is E15. After John gave a presentation about a project that he had done within another group, Paul asks John whether he has also calculated the theoretical minimum of the variable he is interested in. John says that he had not thought about that possibility. Subsequently, Paul writes the variables he assumes to be important on a whiteboard, develops them into equations and deduces a formula for the theoretical minimum. Thinking along with somebody is not restricted to single face-to-face meetings of two or a few persons. At cluster meetings or presentations for a whole group, attendants can come up with new ideas with regard to somebody else's problem as well. Moreover, thinking along can also be realized in written exchanges, for example when commenting on a draft of a report written by somebody else.

We observed three different ways in which thinking along contributed to the practices of researchers. First, it enhanced creativity by generating possible solutions.

Second, it enhanced reliability by evaluating proposed solutions. Third, it stimulated reflection by asking questions. We discuss this in greater detail.

First, in many cases, thinking along contributed to research practices by proposing solutions, ideas or hypotheses. For instance, in E209, Malcolm presents a new research idea to 15 other group members at a lunch meeting. He describes a basic reaction, known to many chemical researchers, which has not been industrialized yet since it proceeds very slowly. Malcolm explicitly asks his colleagues for ideas about how to speed up the process and to overcome some other difficulties. Although these questions are new to his colleagues, they indeed come up with two possible solutions that raise the enthusiasm of Malcolm. By the use of different perspectives, backgrounds, experiences and frames of reference, others may come up with ideas a researcher himself had not thought about. But even persons with a relatively comparable knowledge base may come up with additional hypotheses (Okada and Simon, 1997). Coming up with new ideas and questions is a creative process that has unpredictable properties. Existing knowledge might even hinder creative processes. Malcolm told afterwards that he did not tell about the solutions that he was already considering, in order not to narrow the focus of his colleagues. Suggestions for technical solutions, hypothetical explanations and ideas for experiments that are created by thinking along are not necessarily valid or effective, but in research the breadth of possible solutions considered is an important predictor of the quality of the final solution chosen (Allen, 1977).

Second, in some cases thinking along contributed by helping to determine the validity of solutions and therewith enhancing the quality and acceptance of research results. Thinking along may yield evaluations, arguments, agreements and rejections. As

Thagard (1997) notes, it is often easier to identify mistakes in the work of others than in one's own work. In E229, Geoffrey phones with a PhD-student that he supervises. This student, Eric, tells that he has tried to solve the same set of cubic equations in two different mathematical software programs, which yielded different results. Eric says to Geoffrey: *"I have been struggling with it for more than a week and I still do not understand why the results differ"*. By e-mail Geoffrey received the lines of his programmed equations and he looks through them while he has Eric on the phone. Within ten minutes, he discovers two mistakes in the lines of Eric. A corollary effect of thinking along is that it may lead to adopting or changing the degree of belief one has in a solution. When the other agrees with something or rejects it, this can be considered a reason to change one's degree of belief in it (e.g., Goldman, 1999). In E69, described above, Jason confirmed Luke's weak belief that his filter was good enough. Because Luke considers Jason to be an expert in optical matters, this agreement is for Luke the reason to increase his belief in the reliability of the filter.

Third, in some cases researchers were stimulated to reflect on new issues or to consider additional questions. Other researchers may come up directly with new research questions to explore, but they can also stimulate reflection in a more indirect way, for example by asking critical or open questions. During interactions, such questions come up frequently: *"But isn't it possible to fit everything with eight parameters?", "Why don't you add H_2 earlier, so that the ratio would be 2:1 at the beginning at the process?"* (E268) and *"Does gravity have any effect here?"* (E40). This last question was posed to Jason and opened a new problem for him. He had not considered the possibility that

gravity might have an effect. So he decreased his believe in his current solution and started analyzing the effect of gravity. And indeed it proved to have a significant effect.

Thinking along is related to, but distinct from a number of other concepts. The above paragraphs show that it is broader than advising or giving feedback (Ashford and Cummings, 1983). But thinking along has a more specific meaning than concepts like internal consulting (Allen and Cohen, 1969), technical communication (Tushman, 1978), knowledge sharing and help seeking (Lee, 1997). The generation of new ideas, evaluations or questions with regard to a problem of somebody else, which we labeled thinking along, is a distinct type of internal consulting, technical communication, knowledge sharing and giving help. It has distinct characteristics from a knowledge-based perspective. This will be discussed in the next section.

THINKING ALONG AS A KNOWLEDGE INTEGRATION MECHANISM

In the previous section we reported that a large share of communication in an industrial research laboratory does not consist in the transfer of information or knowledge, but can be characterized as 'thinking along'. Thinking along can also be interpreted as a knowledge integration mechanism. When thinking along with somebody, one develops new ideas with regard to a problem of that other person. This involves the application of two types of knowledge. First, thinking along is enabled by knowledge about the problem, activities and knowledge of the other person. Second, and more importantly for our current analysis, it involves the application of technical knowledge about the topic at hand. Take for example E69, described above. In this episode Jason arrived at a conclusion about Luke's filter that he did not have before. This conclusion was enabled

by the application of Jason's knowledge of optics to Luke's research problem. The resulting positive evaluation was communicated to Luke and incorporated in his practices. This implies that Jason's knowledge of optics is integrated with the knowledge that Luke applies to his own task. In short, thinking along is a way of integrating knowledge.

Thinking along with someone differs fundamentally from knowledge transfer as a knowledge integration mechanism. The knowledge that is applied in thinking along does not need to be transferred. In the example described above, Jason did not transfer the knowledge of optics that he applied to the problem of Luke. Transferring all relevant knowledge about optics to Luke could have taken days or weeks. The application of that knowledge by Jason lasted less than five minutes. Thinking along in communication in fact economizes on communication. Thinking along exploits specialization. In a situation like this, thinking along is a more efficient knowledge integration mechanism than knowledge transfer, since it enables the integration of knowledge without the transfer of knowledge. This is the more important since much of the knowledge used in thinking along is tacit and situated. As Polanyi (1958) argued, doing research is not solely a matter of following explicit methodological guidelines and applying explicit knowledge. Explicit knowing and research progress thrive upon a foundation of tacit knowledge. Coming up with creative solutions, thoughtful evaluations or striking questions takes cognitive skills, intuition and deep understanding. It has frequently been observed that transferring such tacit knowledge is difficult (Collins, 1974; Hansen, 1999). Furthermore, turning tacit and situated knowledge into explicit rules and procedures may seriously hamper its applicability.

Thinking along differs also from direction, routinization and group problem solving, the other knowledge integration mechanisms distinguished by Grant (1996a; 1996b; 1997; 2001). Direction refers to the translation of a domain of specialist knowledge into simple explicit rules and instructions that can be conveyed to others and therewith be integrated in their work processes (Demsetz, 1991). Thinking along differs from rules and directives since it is not a general instruction that is developed and there is no hierarchical relation between the persons involved. Another mechanism, sequencing and routinization, realizes knowledge integration by individual actors knowing their part of a sequence (Grant, 1996b; Nelson and Winter, 1982). Thinking along differs from sequencing and routinization because it is a temporary interaction without fixed roles and not a regularized pattern. Finally, thinking along differs from group problem solving, since it is only a temporary contribution to a problem of somebody else. Of course, these differences make that there are some situations in which thinking along is appropriate as a knowledge integration mechanism, but many other situations in which another mechanism is appropriate. We will come back to that by the end of the next section.

THINKING ALONG WITHIN AND ACROSS BOUNDARIES

Existing literature has stressed that groups centered on a set of practices, develop own languages, artifacts, ways of knowing and ways of problem solving (Boland and Tenkasi, 1995; Brown and Duguid, 1991; 2001; Katz, 1982). Brown and Duguid (1991) and Lave and Wenger (1991) coined these groups communities-of-practice. The development of communities-of-practice may have a double-sided effect. On the one hand, shared practices and shared knowledge enable interaction within a community. On the other

hand, differences in knowledge and practices may create boundaries between communities-of-practice and make it difficult to transfer knowledge across these boundaries.

Within the research organizations different groupings intersect. At the NatLab, for example, researchers were member of a group (e.g., Group Buijs), member of a specific cluster within that group (e.g., coating) and member of a project team (e.g., PolyLed spin-coating) and were further characterized by different scientific background (e.g., chemical engineering or physics) and a position (scientific staff, assistant or trainee). Each of these groupings creates boundaries.

For each of the 36 cases of thinking along that we identified, we classified the people who were interacting with one another as being from the same group or from different groups, and whether they were from the same project or not (see Table 2). There were only 9 instances when someone helped a person from his/her group and project. In the remaining 27 cases, at least one boundary was crossed by thinking along. By thinking along with someone, knowledge can be integrated both within and across boundaries. In most cases, knowledge is integrated at the same time within certain boundaries and across other boundaries.

-- Table 2 here --

Thinking along within boundaries can be found within clusters. The clusters at the NatLab, in which about six researchers participated, are most like communities-of-practice (Brown and Duguid, 1991; Wenger, 1998). Thinking along with each other seems to be a typical way of interacting for the members of these communities-of-practice. Cluster-members work on different projects, but in the same field of expertise

such as ‘coating’ or ‘plastic processing’. In addition to informal meetings, cluster-members meet once every two weeks and tell each other about activities undertaken since the last meeting and the problems they encountered. Since the knowledge of cluster members has an important overlap, they are able to evaluate each other’s work. Moreover, differences in past experience, intuition, creativity and analytical strategies make them also a valuable source of in-depth suggestions. These tacit aspects of knowledge are hardly transferable, but can nevertheless be integrated by thinking along.

The largest cell of Table 2, outside project and within group, also contains interactions between group members with different disciplinary backgrounds. For example, Richard faced a problem in the spin-coating of a polymer layer on optical discs: *“I was getting a strange phenomenon. Using the same parameters every time… the layer was slowly getting thinner and thinner. I couldn’t work it out”*. Richard, educated in physics, wondered that his problem might have a chemical origin. Therefore he went to Andrew, a chemical engineer from another cluster (E44). Andrew came up with the hypothesis that it could very well be that the polymer liquid, which was kept in a bottle, was reacting with oxygen, every time he opened the bottle. The longer the bottle had been open, the more the liquid changed and the more this influenced the spin-coating process. *“That was a breakthrough. I hadn’t even thought about it”*, said Richard. Richard was able to use this explanation (which turned out to be adequate) provided by someone with a different background, though he may not have been able to absorb the knowledge required to think up the hypothesis himself.

Allen (1977) already found that communication with non-project members was more positively associated with project performance than communication with project

members. In a related vein, Pelz and Andrews (1966) had reported a decade earlier that communication between colleagues in the same laboratory but outside the group had a significant impact on fostering a productive R&D climate. Interaction with outsiders may counter traps of group problem solving, like a tendency towards conformity and groupthink (Newell et al., 2002). The concept of thinking along describes one mechanism for this boundary spanning process (Tushman and Scanlan, 1981), which makes use of the existing differentiation in knowledge.

Both within and across boundaries, thinking along is effective as a knowledge integration strategy when it is unpredictable what knowledge might be fruitfully applied to a task. One of the goals of cluster meetings and group meetings is to let people think along with each other, but it is often unpredictable who is able to help in what way. What knowledge can be applied to a research problem differs over time and cannot be predicted fully in advance. The same holds for thinking along across boundaries. The help received could often not be envisioned far in advance. Thinking along may establish temporary interaction between elements of a loosely coupled system (Orton and Weick, 1990; Ravasi and Verona, 2001). However, when the same knowledge needs to be applied to the same type of task over and over again, other knowledge integration mechanisms, like routinization and direction, may be more effective. When the same knowledge needs to be applied to the tasks of the same person over and over again, it is more efficient to transfer the required knowledge to that person. Finally, group problem solving is more suitable when the scope of the knowledge that has to be integrated is larger and a higher level of involvement is required.

DISCUSSION AND CONCLUSION

This article has described a particular type of interaction that is widely used among industrial researchers. This type of interaction consists in the generation of new ideas, comments or questions with regard to a problem of somebody else. Adopting the expression used by some of the group members we studied, we labeled it 'thinking along'. Our claim that thinking along contributes to the practices of researchers is in line with the repeatedly confirmed importance of technical communication (i.e., informal interactions, knowledge sharing, internal consulting) in R&D (e.g. Allen, 1977; Keller, 1994; Pelz and Andrews, 1966; Tushman, 1978). However, the concept of thinking along provides a more specific analysis that applies to a part of the technical communication between researchers, therewith separating it from other types of communication. Whereas other types of communication may legitimately be interpreted as the transfer of existing information or knowledge (e.g., Tushman, 1978; Hoopes and Postrel 1999), in thinking along the temporary application of knowledge and the generation of new ideas, comments or questions are central.

This difference becomes especially relevant when we analyze communication from the perspective of knowledge integration. Both knowledge transfer and thinking along constitute ways to integrate distributed knowledge. By thinking along, knowledge is not integrated by transferring it, but by applying it temporarily to a problem of somebody else and communicating the generated ideas to that other person. Thinking along exploits knowledge differentiation since the person who has the knowledge applies it. The value of thinking along is the opposite of what it is suggested to be on superficial

analysis: instead of transferring knowledge, its value is that knowledge does not need to be transferred.

Different knowledge integration mechanisms will be useful in different situations. Thinking along seems to be particularly useful when the knowledge that has to be used is tacit and therefore hard and costly to transfer. Furthermore, thinking along can be used to integrate knowledge within and across boundaries. The concept of thinking along elucidates interactions that take place within a community-of-practice (Brown and Duguid, 1991; Lave and Wenger, 1991). The circumstance that members of a community-of-practice share a common knowledge base, but differ in past experience, insight and intuition makes that they can fruitfully contribute to each other's problems. Thinking along was also used to get help from persons outside communities-of-practice. Both within and across boundaries, thinking along seems to be particularly useful when the relevancy of re-combinations of knowledge was unpredictable. In contrast to rules and routines, thinking along is a flexible mechanism for knowledge integration.

Our findings imply that knowledge management practitioners should differentiate between the support of knowledge transfer and the support of thinking along. The dominant codification approach to knowledge management consists in codifying knowledge and storing it in databases or intranets, where it can be accessed and used by all organization members (Hansen et al., 1999). This approach supports the transfer of (explicit) knowledge, but it does not support thinking along. Thinking along may be supported by what has been coined a personalization approach to knowledge management (Hansen et al., 1999). Next to enabling the transfer of tacit knowledge (Hansen, 1999) and providing richer communication that is able to deal with ambiguities

(Daft and Lengel, 1984), a personalization strategy may also serve to provide opportunities for the discussion of each other's work-related problems. Yet, thinking along requires a particular elaboration of a personalization strategy. Organizations can design structural arrangements to create opportunities for thinking along, like the clusters and cluster meetings and the internal manuscript review procedure at the NatLab. More spontaneous cases of thinking along are enabled by mutual knowledge on who knows what and who works on what problems. Formal and informal meetings yield this knowledge about others, but 'yellow pages' systems may contribute as well. Finally, feeling responsible for others and believing that others may provide a valuable contribution to your work are highly relevant conditions for thinking along.

This article presented an exploratory study of knowledge integration in industrial research. It has been limited to the discussion of one knowledge integration strategy employed in interactions between industrial researchers. More exploratory studies of knowledge integration in other organizational functions, across organizational functions and in other types of organizations are needed. A specific question is whether the strategy of thinking along can be found in other situations as well. Characteristics of thinking along – its generative nature and flexibility – particularly suit research environments, but we expect that thinking along is not limited to this environment. More generally, more research is needed to develop and test a theoretical framework that relates knowledge integration mechanisms, situational characteristics and organizational outcomes.

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Table 1: Characteristics of the Ethnographic Studies

	Group Buijs	**OGIR**
Period	April – Oct. 1999	March – Sept. 2001
Days at research group	45	31
Introductory interviews	22	23
Researchers 'shadowed'	4	2
Days 'shadowing' researchers	19	8
Interactions observed	174	71
Interactions analyzed quantitatively	57	52

Table 2: Distribution of Cases of Thinking Along

	Within group	Outside group	Totals
Within project	9	8	17
Outside project	16	3	19
Totals	25	11	36

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