

Organizational Learning: Evidence from Knowledge Management

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Abstract: Despite the importance of knowledge management and organizational learning, some important questions remain unanswered. This study attempts to find the link between organizing and learning. Specifically, it aims to focus on understanding the links between practices of knowing and practices of “coordinating” in project teams. Collective coordination is created to deal with the effect of knowing and how the coordinated solutions arising from this coordination practice influence the next knowing practices. Using the Actor Network Theory (ANT) in three project teams to explore the relation between learning activities and “networking” activities deploy a longitudinal and qualitative study. Findings indicate that coordination as a dynamic, socio-material, heterogeneous “constellation” characterized by ongoing learning, transformations and reconfigurations during “controversies”. In addition, “constellation” of coordination mechanisms affects the capacity of actors to create and share knowledge.

Key words: Coordinated, collective, heterogeneous, knowledge, capacity, practices

INTRODUCTION

Managing organizational knowledge to improve a firm’s performance, requires an understanding that organization is as a system of knowledge. Existing literature indicates that knowledge management analyzed knowledge at an organizational level, whilst the process of knowledge creation at the micro-level remains less explored.

This study contends that knowledge management theories neglect micro-foundations and it posits that it is necessary to explore the micro-practices (Rouleau, 2005) to understand how actors concretely learn, create, transform their knowledge during their daily practices. This new level of focal analysis may improve and renew the understanding of the knowledge dynamics. Moreover, most of the theories of knowledge management have offered a functionalist understanding of knowledge by creating dynamics in organizations (Nonaka, 1994; Nonaka and Takeuchi, 1995; Sanchez and Heene, 1997). The theories focus on the role of knowledge assets as the determinant of a firm’s competitive performance. Nevertheless, the presupposition that knowledge can be treated as an objective commodity seems to overlook the highly interactive, provisional and controversial nature of knowledge. Thus, a lot of learning practices remain unexplored and thus provide some explanations for the failures in knowledge management practices. An exclusive focus on performance overlooks the more fundamental relationship between knowing and organizing (Weick, 1993). Focusing on such a relationship poses a

double-challenge for the researcher (Lanzara and Patriotta, 2001). On the one hand, it entails spelling out how processes of knowledge creation may lead to the emergence of novel organizational arrangements. On the other hand, it involves understanding how specific features of organizational settings may facilitate or hinder individual and collective learning. This study investigated the fundamental relationship between knowing and “Coordinating”. Intra-organizational coordination is a fundamental principle of all organizations. However, very few studies tackle the impact of this principle on a firm’s capacity to manage knowledge. To explore this relationship, a focus on a specific context is an innovational project. The objective is to analyze the mutual relation between coordination process and knowing process.

Intra-organizational coordination has been intensively studied (Mintzberg, 1993) with a contingency perspective. These studies claim that each type of interdependence fits a single appropriate coordination mode. Though, no detail is ever given about the way of constructing these coordination modes. This study intends to show that these coordination modes such as mutual adjustment, direct supervision, etc., do not represent the way actors actually coordinate in practice. For example, direct supervision or mutual adjustment is only means to achieve a solution, rather than the solution itself. Therefore, a new conceptualization of coordination as a socio-material process is proposed. The results of this process are the solutions of coordination supported by a network of human and non-human actors.

These solutions have been rarely studied, thus remain “black boxes”. To open these “black boxes” and to know how the pragmatic solutions of coordination are “crafted” in organizations an Actor Network Theory (hereinafter, referred to as ANT) approach is adopted (Latour, 1987, 2005). The coordination of the process made by a network of human and non-human actors is achieved by the implementation of the ANT. The non-human actors such as physical objects, rules, goals or minutes of meetings do impact the coordination process. Using the ANT as a research strategy (Lee and Hassard, 1999), three project teams have been studied over a period of 3 years. Teams made up of five or seven students carried out a technological project which could lead eventually to great innovations. Following the methodological recommendations of the ANT, a wide and rich variety of data sources including interviews, archival data, access to groupware, access to mailing lists, artifacts, observations of brainstorming situations and meetings have been collected.

This study displays some insights concerning both the understanding of coordination and the interplay between coordination and knowing. First, it reveals that for a single type of interdependence, teams create a complex constellation of coordinated solutions. This result renews the conception of intra-organizational coordination and implies some reservations to the conclusions of contingency theory. It is important to note that in order to understand the coordinating practices, one cannot take into account one solution irrespective of other solutions. Each different coordination practice impacts the others mutually. Therefore, the adequate level of analysis lies in the constellation and not in a single solution of coordination alone. Secondly, some elements of this constellation of collaborative coordination are sometimes unstable and change in an ambiguous way during actual work practices. The longitudinal exploration reveals that the stability (or instability) of these elements is accounted for by three processes: a learning process, a legitimating process by coalitions of subjects sticking up for themselves and a community process. Thirdly, another result of the comparative analysis amongst teams is that solutions of collaborative coordination in a similar context are not the same for each team. Teams have some common tools such as risk assessment individual and collective goals assignation, self-assessment rules and deadline reports; however, they interpret and transform these tools in a knowledgeable and legitimate practice. This transformation is led by “sense making” (Weick, 1993). Hence, coordinated solutions are “crafted” and “transformed” during the process of solving practical problems. Finally, processes

of collaborative coordination and processes of knowledge acquisition impact one another. The solutions of coordination are fabricated through a learning process which depends on the extant constellation of collaboration mechanisms. To be more precise, there are two types of coordination mechanisms. In a single constellation, some coordination mechanisms create order and bring stability while supporting the conservation of knowledge. Surprisingly, the other creates disorder and brings instability and supports deep learning. Moreover, the compromise between exploitation and exploration of knowledge depends on the structure of the constellation of coordinated solutions.

Collaborative coordination processes; Socio-material learning processes:

Intra-organizational coordination is a classic issue in management science and organization studies. Most of these studies about collaborative coordination adopt a contingency perspective. Thus, we know little about the way coordination is put into practice and there is little empirical evidence showing how collaboration happens in everyday practices. Conceiving coordination as a socio-material process of interactions sheds some light on parts of collaborative coordination activities that are still unclear.

The coordination; A classic issue, not always topical:

Coordination is a classic issue and is always topical with organizational mutations and reconfigurations. The coordination issue was tackled as a key problem in organization management by the founding researchers in management science. Coordination means binding together, unifying and harmonizing all activity and effort. Urwick develops a theory of organization based on the formalization of ten concepts, one of which is coordination. The objective of coordination is to combine efforts towards a common goal by synchronizing individual and collective performances available in each department. Finally, coordination is one of the seven principles of organization by Gulick. It is also characterized by the intent to make an effort towards converging common goals. Van-De-Ven *et al.* (1976) note, “coordination means integrating or linking together different parts of an organization to accomplish a collective set of tasks”. Therefore, coordination is a way to create coherence. Its quality is the crucial parameter of the organization’s durability (Barnard, 1938). Coordination activity exists in each organization because the coordination is the corollary of the specialization. However, the issue of coordination is always topical. Indeed, some studies revive the conception of coordination like the coordination theory by Malone and

Crowston (1994) and Crowston *et al.* (2004) conceiving coordination as energy in conversation (Quinn and Dutton, 2005) or the alternative conceptualization of coordination activity from Alsene and Pichault (2007), Amblard *et al.* (1996) and Argote *et al.* (2003). Intra-organizational coordination has been intensively studied (Mintzberg, 1979) in a contingency perspective (Crowston, 1997). These studies advance that each type of interdependence fits a single appropriate coordination mode. Thus, much of the current understanding of coordination lies in the premises of organizational design (Heath and Studenmayer, 2000). These various theories argue that firms organize a response to uncertainty in both task and environment and select the most appropriate coordination mechanism. March and Simon (1958) identify two modes of coordination: plan (formal rules, planning and system of control) and retroaction (transmission of new information during the course of action). Thompson (1967) hypothesizes three coordination mechanisms-standardization, plan and mutual adjustment-used in response to three different patterns of dependencies: pooled, sequential or reciprocal. McCann and Galbraith challenged the utility of Thompson's construct by asking "are three pooled interdependencies greater or less than one reciprocal interdependency?" This ambiguity in Thompson's development lowers the effectiveness of his construct as a toll for problem solving in organizations. Other typologies use a plethora of variables: task uncertainty and unit size (Van-De-Ven *et al.*, 1976) interdependence level (Cheng, 1983), differentiation of the inter-unit conflict. Mintzberg's typology is the most famous: each mode of coordination is tightly adapted to one organizational configuration.

Nonetheless, these studies are to some extent unsatisfying because the practice of collaborative coordination still appears to be ambiguous and vague. The frequently adopted level of analysis (organization, work unit) does not permit assessment of the complexity and the fullness of such a practice. Finally, the coordination mechanisms distinguished in the sources do not necessarily portray the real adjustments of organizational actors (Alsene and Pichault, 2007). For example, direct supervision or mutual adjustment is only a means to achieve a solution, rather than it is the solution of coordination itself. Indeed, the outcomes of mutual adjustment may be manifold: dispatching work tasks, setting deadlines, defining new objectives. Therefore, the classic modes of coordination shed little light on the way which actors effectively coordinate during any course of action.

In order to achieve a more faithful description of coordination practices developed by actors, it is necessary to focus on the level of interaction and explore

the micro-practices designed to solve a coordination problem. The focus on interaction allows us to use the same framework with both order (coordinated elements) and change (a new coordination in the course of action). Two types of interactions are studied: interaction amongst actors and interaction between actors and their working environment.

The solutions for coordination as the results of a socio-material coordination process

Coordination as a process: "Processes of coordination as such remain black boxes relatively closed. I know few things about these processes and we have only few tools for their understanding" (Alsene and Pichault, 2007). In this study, we must open these black boxes. Moreover, we must endeavor to understand how the coordination is crafted and is modified day by day. I consider the coordination activity as a set of practices which result in a set of more or less effective solutions of coordination. This new perspective emphasizes the role and the creativity of employees in the coordination process. It is quite consistent with Barnard's definition: "The creative side of organization is coordination" (Barnard, 1938). Solutions of coordination are therefore, more the result of a craft, a "bricolage" than they are the result of a rational design process. These solutions of coordination are the outcomes of individual and collective experiences and not from a linear process of selection. This "bricolage" can be understood as a cognitive and social learning process. Learning in fact knows how to coordinate and the solutions of coordination created are the outcomes of the learning process. With this new conceptualization of coordination, one can make a connection between the process of knowledge creation and the organization as the result of this process.

Objects and coordination: In order to have a faithful description of the coordination practices, we must argue that the role of objects should be reintroduced in analyzing the processes and solutions of coordination. Indeed, management sciences have focused more on inter-individual interactions, social networks and group dynamics and less on interactions between subjects and objects. These interactions always are given little attention even if they play a role in action. We cannot understand the coordination of a cyclist without analyzing such interactions with the bicycle or understand the coordination of a pilot without analyzing interactions with the cockpit. So, it is necessary to reintroduce the role of objects in order to understand the comprehension practice. Indeed, how can we understand the organizing of a project team without analyzing its

interactions with prototypes? How can we understand the management practices adopted by an engineer if we do not focus on the performance control tools? How can the dynamics in a social network be understood without considering how it interacts with the other subjects? Objects have various effects: constraining, enabling, conveying knowledge, facilitating memorization. In this study, we consider the role of objects in the understanding of the organizing process. Therefore, we analyze how objects may be help or a hindrance to structuring the socio-material context, to the coordinating process.

Actor network theory and organization: With the help of actor-network theory (Latour, 2005), we can define coordination as the process and the result of the “translation” (Callon, 1986) developed by the network of human and non-human actors. I chose the ANT as a research strategy for three reasons: in order to analyze a process with unclear boundaries, to consider objects in action and to conceive action as an open-ended and non-determinate process.

In a world where market constraints have led organizations to maximize the flexibility of both their internal and external relationships, to use a research strategy enabling one to follow the construction and the moving of the barriers is interesting as it does not impose or defend its own categories and classifications. Ontological relativism of the ANT permits one to track such processes and practices (Lee and Hassard, 1999). This approach matches a tendency that leaves formal and functional behaviors of the organization aside as it favors the study of processes and organizing practices which is the study of the socio-technical organization (Bloomfield and Vurdubakis, 1999; Calas and Smircich, 1999; Lee and Hassard, 1999). The solutions of coordination are not predetermined. I identify these solutions at the same time as I discover the process of coordination. This perspective seems to leave aside a formal and functional conception of organization and focuses on the study of the organizing process in order to be more precise on the study of socio-technical organization (Bloomfield and Vurdubakis, 1999; Calas and Smircich, 1999; Lee and Hassard, 1999). Indeed the actor-network theory concerns the networking activity, the activity by which a socio-material network is built. Thereby, this research strategy is indeed highly consistent with the idea of an emergent construction of solutions of coordination and its reconfiguration in practices. Thus, the activity of coordination is seemingly an attempt to stabilize interactions by creating socio-material solutions. In this first part, I argue that

solutions for collaborative coordination are built up by a learning process. In the next part, I study how these solutions of coordination impact the process of knowledge acquisition.

The construction of knowledge by organizing: The relation between the process of knowledge creation and the coordination process is not unilateral. I have studied in the first part the impact of learning process on coordination; I will now discuss the role of coordination solutions in the process of knowledge creation.

From knowledge as a stock to knowledge as a process: Knowledge issues have been critical to organization for some years. Knowledge management, organizational learning, communities of practices are at the heart of management academics and professionals concerns. But, the concept of knowledge is very ambiguous (Tsoukas and Vladimirou, 2001). Its interpretations are multiple so, knowledge management as a research field is not really structured (Scarbrough and Swan, 2001). Indeed, there are major divergences regarding methodology and epistemology. I identify a pair of perspectives in this research area.

The first one is based on an epistemology of possession (Cook and Brown, 1999) and deploys a functional view of knowledge. Knowledge is considered as a stock as an asset which can be used to improve firm’s performance. This conception of knowledge is widely shared in studies on information systems and in the knowledge-based view theory (Grant, 1996a, b; Kogut and Zander, 1992; Spender, 1996; Schendel, 1996). In this perspective, knowledge has an existence of its own, regardless of the subject. Then, the subject does not create new knowledge by adaptation by “translation” (Gherardi, 2000).

The second perspective is based on an epistemology of practice (Cook and Brown, 1999). The knowledge is not described as a stock used in action but as a part of action. This new perspective lead to a semantic change: the term “knowing” substitutes for the term “knowledge”. As Cook and Brown notice, “we use the term “knowing” to refer to the epistemological dimension of action itself. By “Knowing” we do not mean something that is used in action or something necessary to action but rather something that is a part of action, both individual and group action” (Cook and Brown, 1999). This new perspective is shared by the situated learning theory (Lave and Wenger, 1990) by the studies about the communities of practice (Brown and Duguid, 1991; Wenger, 1998, 2000) and more generally, speaking by the practice based theorizing (Gherardi, 2000; Blackler, 1995;

Clegg *et al.*, 2005). This perspective sheds light on the relational, dynamic, social and cultural dimensions of knowledge. Moreover, this perspective stresses the socio-material context of knowledge creation. So, I argue that this perspective is more adapted to the understanding of the knowing practices.

Actor network theory and knowledge creation: The problem of knowledge creation cannot be tackled without a clear definition of the concept of knowledge. Firstly, knowledge is acquired by action and is situated in ongoing practices (Gherardi and Nicolini, 2000). In this pragmatic perspective, the process of knowledge creation is described as a cognitive process but also as a participation in a collective action. In everyday practices, learning takes place in collective experience, consciously or unconsciously. Cogn processes are not ignored in this definition but they are apprehended as social processes. indeed, actors process information and analyze it by cognitive processes but these processes are situated and embedded in an organizational context. Then, their understanding is only possible by considering contextual specificities.

Secondly, it is relational and conveyed by artefacts. Indeed, “knowledge is not something that people possess in their heads but rather, something that people do together” (Gergen, 1991). Knowledge is built and applied in interaction. So, this created knowledge impacts the upcoming interactions. In return, these interactions will modify the evolution of knowledge. Yet, knowledge exists only if there is a socio-material network to carry it and conversely the network only exists by the creation and the sharing of knowledge. Actors and artifacts constitute this network. Artefacts are little studied in knowledge management research. In fact, we know little things about the interplay between actors and objects (Fox, 2000). I argue that the mobilization of actor-network theory is a good way to understand the different roles played by objects in human activity. First of all, they convey knowledge and can improve the memorization capabilities of an organization (Hutchins, 1995). Besides, the actor-network theory researchers consider that the learning entity can be an actor-network made up human and non-human elements. Moreover, the objects play a role in the ongoing stabilization of the socio-material environment and in the emergence of a collective order (Latour, 2005). Finally, their presence can trigger a learning process in order to manage their effects. These effects are multiple and depend on the assessment capacity and the interpretation ability of actors. Therefore, considering objects in the understanding of knowledge creation does not undermine the cognitive processes. On

the contrary, taking into account a set of affordances (Gibson, 1979, Norman, 1988) allows to have a more realistic description of learning processes. One part of the interplay between knowledge and coordination takes place through the intervention of artefacts. Indeed, artefacts emerge from a learning process in order to coordinate the activity of actors but in return these artefacts impact the next process of knowledge creation by giving directions, constraining the upcoming learning processes.

Thirdly, knowledge is crafted, dynamic and provisional (Gherardi, 2000). Indeed, a trial and error process makes up knowledge by practices of “bricolage” developed by actors (Latour, 1987). Moreover, “knowledge does not exist prior and independent from the knowing subject” (Gherardi, 2000, 1999). So, even if coordination mechanisms such as artefacts, management tools, rules, procedures, carry knowledge, knowledge is rebuilt and potentially modified in each interaction. Then, the solutions of coordination carry knowledge but this latest is provisional. Indeed if these solutions are assessed as unsatisfactory, they could be transformed and so, they can modify the knowledge which is carried.

To study the impact of the solutions of coordination on knowledge, it is necessary to tackle the problem of its measure. This problem is too often evaded in knowledge management research. Here, it is still more complex, because the knowledge is defined as a process. However, “learning is no longer equated with the appropriation or acquisition of a piece of knowledge. If we focus on knowledge as a process (knowing), the supposed distinction between learning and knowledge disappears” (Chiva and Alegre, 2005). So, to understand the process of knowledge creation, I study the learning processes.

MATERIALS AND METHODS

Exploratory case study: In order to explore the inner mechanisms underlying knowing processes in organizations, I follow a qualitative and longitudinal approach to organizational knowledge. So, se opted for this methodology since, exploration of new tracks still rarely studied in literature is made easier by qualitative methodology. Furthermore, I decided to have my analysis relying on case studies because the “case study is a research strategy which focuses on understanding the dynamics present within single settings” (Eisenhardt, 1989). This approach is also well adapted to the analysis of complex phenomena: a case study is an empirical research that targets a contemporary phenomenon inside its real context in which barriers between the phenomenon

and the context itself are not clearly identifiable and where evidence sources are numerous (Yin, 1989). The number of observed cases is always a matter of prime importance. The study of multiple cases was chosen as it enables an analytical generalization of the results (Yin, 1989). The selected project teams follow the same scholarship program in a renowned French engineering school. This common context facilitates comparisons and brings us closer to logic of experimentation (Yin, 1989).

Research design and data collection: During this case study, I varied the kinds of data and the sources of collect. Yin (1989) identifies six potential sources during a case study: participant and non-participant observations, documents, archives interviews and physical artefacts. I retained the four latest and analyzed them according to the Actor Network Theory (ANT). Indeed, ANT as a theoretical framework also induces consequences in terms of methodology. Moreover, ANT is interested in the networking activity in the sense of fabricating a network. Three methodological principles of ANT were selected for this case study: “following actors”, the symmetry principle and “no group, only group formation” (Latour, 2005). The prime methodological advice of ANT is “follow the actors” (Latour, 2005). Instead of adopting a reasonable position and of assigning a predefinite order, the actor network sociology claims to stand in a better position to disclose order emerging after it has let actors deploy the whole range of the controversies they were involved in Latour (2005).

ANT’s advises to follow the actors while they define the situations they face rather than to impose an external definition of what they are and of what they are doing (Latour, 1987, 2005). The arising issue is the reinterpretation of the actor’s sayings by the researcher thus introducing entities hidden behind actors themselves (Latour, 2005). The goal is to observe actors as they are building the environment in which they live and argue about the world they would like to live in.

I believe that a longitudinal and qualitative approach is coherent with this first principle. Yet, a question remains: “where and when “stopping” the network?” In other words where and when shall I decide to stop following the actors (Strathern, 1996)? This problem is similar in network analysis with the “snowball sampling” but it is even more complex in ANT because it is advised to consider human and non-human actors in the same time. Latour considers that the researcher himself/herself must determinate the associations that should be observed. The researcher should also be able to determinate the associations that may be avoided

but no selection criterion is ever given, thus trusting the researcher wisdom. I pretend that this answer is not satisfactory and I chose in my case studies to limitate my research in the same way as actors were limiting their socio-material network. Non-participant observation and interviews allowed us to determinate whether human and non-human actors were inside or outside the network.

The second methodological principle is the principle of symmetry as defined by Callon and Latour. According to them, symmetry concerns commonly acknowledged dichotomies-truth/error, true/false, rational/irrational but also other wider and not yet discussed dichotomies such as social/cognitive, human/non-human, modern/non-modern, sciences/pseudo-sciences. Once, this principle admitted, the researcher must be located in a place from which the attribution of both human and non-human properties can be observed. One of the consequences of this principle application is the consideration of objects for the understanding of the situation. The actor network sociology is not based on a weak statement according to which objects would act instead of human actors. It simply states that no social science would be able to exist without starting from a close and serious examination of which entities are participating in the action, even if this consideration leads us to admit elements such non-human ones. The potential actions of these elements might be extremely various and imply ambiguous effects. Yet, they widely spread through the environment. Then, how to make sense from these elements? Indeed if they have no visible effects on other agents, then they will not provide any data to the observers; they will remain silent and they will stop being actors thus eventually not being taken into account (Latour, 2005). However, objects can produce effects before becoming silent. Latour proposes five solutions to make sense from objects: innovation study, being in front of ignorant users, accident study, archive analysis and fiction. The study observed innovation project conducted by students in first year of the engineering scholarship program, ignoring several thematic, encountering obstacles during their work and archiving files, drafts, reports and so on.

The last question is about the analysis level. Determining such a level cannot be made without choosing a group with already defined boundaries: the individual, the group, the practice community, the organization and the society. Then, in the real world individuals belong to several groups whose conception or points of view might be contradictory. They also can also easily enter or leave a group. In ANT, there is neither group nor level that must benefit any privilege. This

is consistent with the previous principle “following the actors”, it would make no sense if the researcher was imposing its own prior analysis level in other words if the researcher determines the place from which he aims at following the actors. I therefore, focus on the coordination processes and I integrate the different elements that make up these processes them, either human or non-human.

Applying these principles, a 3 years period was spent on gathering the data. The collected documents provided information about prototype evolution, client relationship, organization modes and knowledge created and so on. In addition to the latter interviews were conducted with each actor of the team project during three phases matching the 3 years period of the scholarship program. Finally, observation and physical artefacts have played a key role in this case study. Observation was used in order to understand everyday action from the actors while taking care to the nature of inter-individuals relationships and to the interactions with the actors. Observing the evolution of physical artefacts like pieces and prototype elements allowed me to gain a better understanding of both the coordination and the learning processes. Furthermore, it is especially observed that the management tools such as self-evaluation tools, goals for each deadline and quality controls.

The study of three project teams: The project teams were monitored as more and more firms are using projects to accelerate their innovation capabilities. Moreover, during projects, traditional structures are missing and the time left for socialization is highly limited. This is why they are considered as an interesting context to study how both coordination and cooperation emerge out of interactions. The case study is based on the study of three conception projects, all led by students of a Kuwaiti engineering school. Each team is made out of three or six people. Each project is over a 3 years period.

Each student is granted 400 h to complete the project, thus meaning a total of 2000-2400 h per group. Projects have been initiated for various reasons: a single student proposition an idea resulting from a brainstorming, a firm’s innovation project, a research lab projects. The final goals are also various among teams and differ depending on actors: solving a problem, creating a prototype, developing innovation, organization and project management abilities; improving learning capacities of the students, bringing them closer to reality.

A study is conducted on the three innovation projects concerning various fields and technologies: an experimental finance software, an automated guitar fabrication tool, a packing system for a carrier company, an automatic barbecue and a motive power based system for electricity generation.

First of all, every team has a scientific advisor, responsible for the scientific and technological evaluation of the project, a “pilot” having in charge every non technical aspect and of course the client partner. The common mission of these three actors is the project evaluation.

In addition, the team goals are defined with a standard tool, common to all project teams. These goals are gradual and correlated to an overall mark. They are measured with a scale of range 0-4, used to evaluate learning in several fields.

Deliverables: Product conformity to the specifications and the satisfaction of the partner (industry or research).

Scientific method: The quality of the problematization, the exploration of every assumption along with its test, the systematic rigor of the analysis.

Project management: The quality of the communication among all partners, the deadline respect, the budget control.

Academic defense: The overview of the approach, the prototype testing, the answers given to clients and researchers.

Documentation and scientific enhancement: Collaborate casting, commercialization, patent deposing, award winning strategy, research creation, participation to scientific events (workshops, symposia, conferences).

Individual goals are evaluated with the same kind of scale. The project-engineering department has built three criterions: group working ability, project management and 18 technical abilities. Each team and each student are therefore, evaluated with an a priori standard tool. Yet, uses and representations of this tool highly differ depending on teams, leading to different impacts on organization modes. Indeed, one team decided not to use this evaluation framework or more or less consciously “forgot” to do so while another is using it during every meeting with the advisors.

Furthermore, project management procedures are also the same for all groups: a convention linking the school, the team and the client; a risk management procedure; a self-evaluation tool; guidelines concerning intermediate reports and defenses. Each team has also access to common resources: the school intranet which includes methodological advices along with analysis, tools, the advisors (professors or associate professors) to help project development. So, these projects are advancing in very close organizational contexts.

RESULTS AND DISCUSSION

The empirical research exhibited a constellation of coordination solutions that allow actors to deal with their interactions. In a given organizational context, I do not observe any predominance of any mode of any coordination solution. Every team I have studied has created its own constellation of coordination solutions. This result tends to mitigate the conclusions of contingency theory concerning coordination among members of a team.

I am not criticizing contingency theory since, I am simply pinpointing its inability to explain the emergence of coordination among members of the teams I observed. The complexity of interactions in a team requires setting up of a combination of solutions rather than the implementation of a prevailing coordination mode. Moreover, this result is important as it changes the level of analysis: in order to understand coordination, one has to study not only a single coordination solution but also a constellation of solutions.

Furthermore, the coordination scheme provided by the organization (grid of goals, procedures, project reviews) does not systematically help to understand how the team is really working and interacting. Coordination cannot be enacted as it is built collectively during a process of organization of negotiation of translation. For instance, the grid of goals is used in various ways depending on the teams. Two of them have elected a member responsible for every category (deliverable, scientific approach, scientific management, public defense and enhancement) while the three others have dealt with each goal collectively. These highly different coordination solutions are resulting from the different ways the available tools are “learnt”.

Actors transform tools that are proposed through their enactment. These tools will be used if the members of the team or the project advisors are able to have the decisiveness of these tools understood by the group. In their turn, the selected coordination solutions lead to different knowledge creation processes. The solutions selected by the two groups have led to processes of knowledge creation that were mainly individual while the learning developed by the three other teams was more collective. Therefore, choosing a coordination solution has heavy consequences on the processes of knowledge creation.

The third result of this longitudinal study is that there are links between the coordination solutions. These solutions that already exist in the team impact the current coordination process. They are the product of a specific context resulting from past practices and

translated in the current ones. “It’s always the product of specific historical conditions resulting from previous practice and transformed into present practice” (Gherardi, 2000). If inside the constellation, several ad hoc solutions have been developed, then the use of project management procedures is very weak while these solutions are often more efficient. According to a mechanistic approach to coordination, actors who compare coordination solutions would have chosen project management procedures. A two-folded explanation can be given about this result. The first one focuses on the coordination process itself and is located at the interaction level. The second deals with knowledge creation and its location is at the constellation level.

Firstly, ad hoc solutions come out of controversies related to disagreements about the organization or about the technical solutions that should be set up. Groups of actors then “problematize”, make “investments in forms” (reports, meeting organization, definition of a new rule of organization) in order to attract and recruit other members of the team. This drawn-out process, consuming both time and energy, allows them to fabricate a satisfying coordination solution in order to stabilize the team functioning.

Consciously or unconsciously, actors sometimes prefer to ignore alternative solutions of coordination in order to preserve the stability of the network of human and non-human actors. Reconsidering the existing coordination solution is therefore, even more difficult at the level of investments in forms. Secondly, moreover by elaborating these ad hoc solutions, actors have developed a new knowledge of self-organization that has become nearly a reflex action once they have to deal with other interactions.

CONCLUSION

This qualitative research provides some insights concerning both the understanding of coordination and the interplay between coordination and knowing. Firstly, I show that for a single type of interdependence, teams create a complex constellation of coordination solutions. This result renews the conception of intra-organizational coordination and implies some reservations to the conclusions of contingency theory. Note that in order to understand the coordinating practices, we cannot take one solution regardless of other solutions. Each different coordination practices impact mutually with one another. Therefore, the adequate level of analysis lies in the constellation and not in the single solution of coordination by itself. Secondly, some elements of this constellation of coordination are

sometimes unstable and change in an ambiguous way during working practices. Hence, coordination solutions are “crafted” and “transformed” in the process of solving a practical problem. Finally, processes of coordination and processes of learning impact one another.

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