Chapter 9

Learning about interdependencies and dynamics

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As mentioned in previous chapters, the companion modelling approach is based on principles laid down in the ComMod Charter (Collectif ComMod, 2005). In this founding document, two fields of application were identified: to produce knowledge on the social and ecological systems under study and to facilitate cooperation between different stakeholders involved in a participatory process.

The process invariably involves a group, one that may or may not be constituted specifically for the companion modelling experiment. This group is composed of both scientists and individuals representing social groups and their interests. These stakeholders formulate different and even contradictory viewpoints about the complex social and ecological system related to the issue raised. It is assumed that the viewpoints of all participants are legitimate, even if the foundations for this legitimacy may differ. The knowledge, on which they are based, whether empirical or scientific, is consequently considered to be relevant. The facilitator of a ComMod process will seek to draw out each participant's knowledge and opinions to clarify the hypotheses on which their arguments are founded in order to share them within the group. Thus, they may be understood and internalized by each member (Chapter 2).

Commodians assume that the involvement of participants in a companion modelling process contributes to modifying their viewpoints, opinions and representations. Through their interactions the ComMod participants learn about themselves, others, their relationships and interactions. During the whole process, from the acquisition of knowledge on the context (Chapters 4 and 5) up to possible agreement for action, the facilitator combines modes of information production and exchange between individual participants and with the commodians. The ComMod approach is sequential, adaptive and iterative. As shown in Chapters 1 and 2, workshops in which stakeholders and commodians interact play a key role in the dynamic of the process.

The objective of this chapter is to elaborate the issue of learning and answer the question: whether and how does the ComMod approach enable participants to learn for collective renewable resource management? More precisely, the objective is to gain a better understanding of how participation in a ComMod process enables participants to learn collectively about complex socio-ecological systems, multi-level interaction, their dynamics and interdependencies. The second objective is to describe the types of learning achieved and the dynamic of this learning. In other words, we call into question the postulate that the activities in ComMod workshops play a fundamental role in the learning process. Indeed, individual participants are involved in collective key moments[1]. Each of them has their own representation of the issue. The modelling approach aims to create a shared representation of a complex system, multi-level interactions and emerging overall dynamics. At the workshops, participants interact, express and discuss their viewpoints, but from what moment does real learning take place? How is the move made from the expression of multiple perceptions to a shared representation that is legitimate in the eyes of all ComMod participants?

In the next sections, we first review different learning theories and build a theoretical framework about learning. This framework enables us to analyse the learning triggered by the ComMod processes and to illustrate it through various examples. The last section discusses some elements likely to enable the consolidation of learning in ComMod processes.

Learning theories related to a companion modelling approach

We define learning as the acquisition of knowledge for effective action in the domain of existence (Maturana and Varela, 1992; Röling, 2002). Now, according to the ComMod Charter what is particularly involved is questioning how a sum of individual learning may lead to the emergence of collective learning. 'Such a family of models is a genuine knowledge-based system allowing interacting researchers and stakeholders to increase their personal and common knowledge of the system, current processes, and the situation of each actor-observer in such processes' (ComMod Group, 2003). What is the relation between individual and collective learning?

Towards a cognitive theory of individual learning

A historical review of academic thought about learning shows that until recently, three main schools of thought, that is, behaviourism, gestalt theory and cognitivism, have dominated debates over learning revolving around the central question: 'how does someone learn and retain what he learns?'.

In the early 20th century, behaviourists such as Watson, Skinner and more recently, Deutsch, Krauss and Fischer focused on response stimulus behaviour. In their view, learning occurs through action, through a process of trial and error. Therewith, they rejected any explanation of observed behaviour by mental processes. Tolman was the first who

[1] We will not address here the issue of the representation of social groups that was discussed in Chapter 5.

considered contiguity and reinforcement of events as the principle explanatory variables of learning, but acknowledged that mental processes also play a role (Lecocq, 2007).

In the Second World War, the Berlin school under the impetus of Wertheimer, Koffka and Köhler developed the gestalt theory. They disagreed with the behaviourist vision of learning because it does not include 'perceptive gestalts'. Proponents of the gestalt theory noted that we perceive objects in a global manner. Therefore, numerous components of reality are perceived simultaneously. Sensory fields order and give rise to segregations, articulations and regroupings (Dubé, 1990). This represented a real change in thinking about learning. As with gestalt theory, the whole gives sense to the parts, contrasting sharply with the atomist vision of behaviourists based on the principle of contiguity between elements (stimuli and response). In the view of cognitivists, behaviourists pay too much attention to isolated events, stimuli and visible behaviour without tackling the set of mental processes in which they are inserted. While behaviourists address the issue of learning through a relationship to the environment, cognitivists are more interested in perceptions, and in the learner's representations. They consider them as elements of a pattern, of a whole brought into play during the learning process. In their view, learning is more a modification of knowledge than a pure modification of behaviour. The cognitivist approach draws from the group dynamics psychology work of Lewin (1946) and on criticism voiced by linguists of the Chomski school (Lewin, 1946). The psychology works of Piaget and Vytgotski on the cognitive development of children have influenced greatly cognitivists (Goupil and Lusignan, 1993). Piaget criticized the analysis of the fundamental processes of knowledge acquisition. He showed that learning constructs itself due to processes of balancing cognitive structures in response to environmental stimuli and constraints. Vytgotski proposed that the process of knowledge acquisition starts from the social (interpersonal knowledge) towards the individual (intrapersonal knowledge).

Over the last two decades, recent theoretical developments within the cognitivist field enabled the learning observed within ComMod processes to be analysed. These developments are positioned within a constructivist perspective, which considers social reality as a permanent construction process. There are multiple perceptions of social reality. Knowledge of this reality is distributed among each of us, with each individual able to understand only a part. Experiential learning theory is based on the four principal stages of cognitive development identified by Piaget: sensorimotor, perceptive, representative and operational. In his work, the French psychologist insists on the necessity of using different experiences in learning. During these experiments, the learner (for him, a child) is led to manipulate objects and proceed to concrete tests. In doing so, he is lead to reflect on the results of, or the questions raised by, his experiences (Goupil and Lusignan, 1993). Following Piaget's proposition Bruner (1960) explored the links between mental and learning processes, especially those associated with methods of discovery and exploration. He showed the strength and durability of learning thus achieved. Kolb (1984) clarified the mechanisms. He considered that individuals learn through a cycle that alternates between stages of theoretical exploration and experimental practice (referring to Piaget's sensorimotor stage), observation (Piaget's perceptive), reflection (Piaget's representative) and action (Piaget's operational) (Piaget and Inhelder, 1984). This learning cycle, known as 'Kolb's learning cycle', serves as a theoretical reference, especially for interactive training approaches. Within the cycle (Figure 9.1), an individual undertakes an action without necessarily thinking about it. Then, he observes and reflects on his action and

experience. Next, he interprets the facts and events and integrates them into a theoretical framework. Finally, he uses what he understood to try to predict what will happen next. In experiential learning theory, Kolb considers both the cognitive and the subjective or emotional dimensions of learners, but he does not analyse the influence of the latter on the learning process. The learning cycle then was discussed by Honey and Mumford (1992). They showed that each stage of the cycle mobilizes different conducts and attitudes, different observation and communication aptitudes, different values and beliefs, and all condition the success of learning.

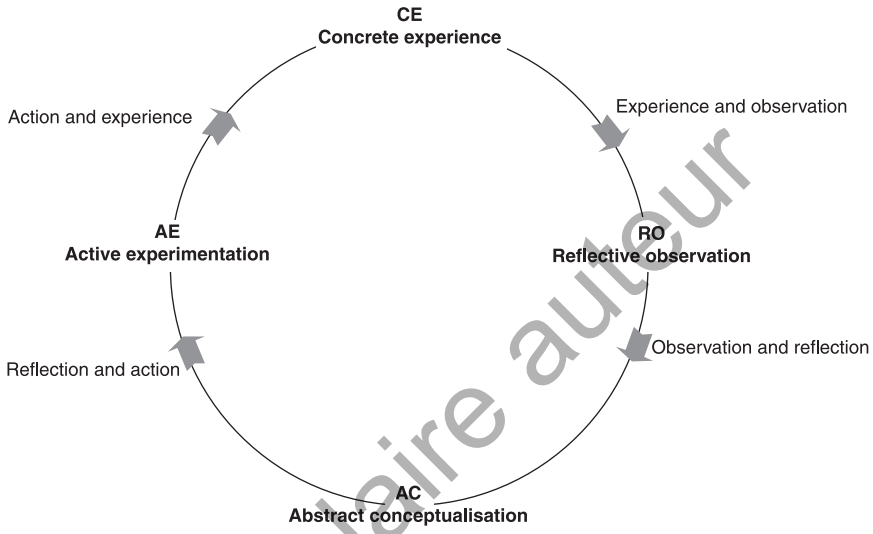

Figure 9.1. Kolb's experiential learning cycle.

The ComMod process is in keeping with the Kolb cycle. It allows participants to experiment with these four experiential learning stages, especially during the conceptual co-construction phase and simulation exercises with role-playing-games (Mathevet *et al.*, 2007). For instance, during a role-playing game session, stakeholders are led to play the game and live a concrete experience related to their daily life (CE), to observe the behaviour of others (RO), to discuss and understand the dynamics and effects in order to induce desired and feasible actions (AC) and then to test them (AE). Moreover, simulations allow virtual experimentation to observe and understand better the long-term dynamics.

Memory plays a fundamental role in the learning process. Not only the immediate memory that passively registers, but the memory that contributes to the phenomena of recognition (allowing one to recognize a previously encountered object) and evocation (evoking an absent, previously encountered object through the remembered image). However, as long as recognition is individual and unconscious, evocation is constructive as this requires the construction of mental structures amongst which are mental models. For Piaget, our permanent and transitory mental models are necessary to recognize the world. They are also 'polarizing filters' of our perception of reality. Operational learning

is committed to memory through procedural habits, or the accumulation of routines, whereas conceptual learning mobilizes knowledge frameworks built with concepts, laws of causality, and semantic and semiotic systems that condition a true 'intelligence' of the situation (Kim, 1993). In ComMod processes, the co-conception and simulation stages are both based on the exchange of viewpoints. They should state clearly the 'polarizing filters' of each participant. Moreover, these stages allow the alternation between conceptual learning (i.e. on the issues under consideration) and more operational learning (i.e. technical or interpersonal skills).

To gain a better understanding of the organizational learning processes, Argyris and Schön (1978, 1996) analysed the mental reference frames of young professionals. They showed that there are two levels of individual learning. Experiential learning remains most often at the first level, known as single loop learning. In the single loop, the reference frame, with its hypotheses based on values, norms, beliefs and objectives to describe the world, is not modified by new learning. This first level only results in changes in practices or operational objectives. This analytical framework seems helpful in understanding the learning of participants in ComMod processes, that is, the issues involved, the overall components of the problem addressed, the complexity of the resource management system and the possible solutions imagined. The second level, known as double loop learning, leads to a real transformation of an individual. In the double loop, the learner questions the foundations of his reference frames, beliefs and hypotheses, and the norms and values he previously held (Argyris and Schön, 2002). Single loop learning generates small operational and cumulative changes, while double loop learning produces more fundamental, strategic and radical changes (e.g. a change in reasoning where justifications become more ecological than economic).

Major learning theories only consider individual learning in a static manner. During the presentation of more recent theories rooted in cognitive theory, we first looked into the scale of individual learning. This first proposition allowed us to show the relevance of an analytical frame for the ComMod learning process. However, the question remains of how one passes from individual to collective learning.

Dependence between individual and collective learning?

In the ComMod approach, we assume that the interactions between participants with intermediate objects produce meaning and modify behaviours, perceptions and mental models of participants both as individuals and as a group. Hence, the learning realized must also be considered at the collective level. We also seek, therefore, to obtain a better grasp of the nature of collective or organizational learning. When can we consider that learning is no longer exclusively individual but concerns the group as a whole? How does individual learning evolve into collective or organizational learning? What conditions facilitate collective learning?

In the 1970s and 1980s, sociologists and psychologists showed that knowledge is a social construct, historically and culturally enshrined in social settings (Knorr-Cetina, 1981, 1984; Latour, 1987). Recent work by Lave and Wenger (1999), in addition to previous works (Brown *et al.*, 1989; Salomon, 1993) further developed this theme. Firstly, they showed that each individual's cognitive structures are not mobilized outside a precise spatial-temporal and social context. Secondly, they demonstrated that learning is distributed among several people through language, artefacts, and more broadly, the

environment. There is thus a close relationship between individuals' situated learning and collective learning (Brown *et al.*, 1989; Lave and Wenger, 1999). Individuals are not passive receptors. They enter a learning situation loaded with their experience and life history and thus, they actively contribute to the re-construction of collective knowledge.

Now that we have established that individual and collective learning influence each other, we tried to understand better the complex retrospections between these two types of learning. Learning mechanisms have been analysed in numerous collective situations, that is, organizations, practice groups and multi-stakeholder platforms. An organization is a hierarchical group of people with a mission, precise objectives, and coordination and communication procedures to guide its members in their production activities (Weick, 1995; Boudon and Bourricaud, 2002). Practice groups (Lave and Wenger, 1999; Wenger, 1998) are constituted by individuals collectively engaged in the same type of activity. These individuals may work in different organizations but they share a history, knowledge and procedures. They share the same experience, the same perception of a problem and communicate to resolve it. Here, there is no hierarchy or formal coordination between individuals. Multi-stakeholder platforms are constituted by stakeholders who represent categories, positions, perceptions, values and different interests. Therefore, they do not *a priori* share objectives or interests (Aarts, 1998).

Weick (1995, 2001) studied the construction of meaning in organizations. He found that, like individuals, organizations have objectives, rules, procedures and routines that help them work within their field of specialization. In the enactment theory, he shows that with the routines (tacit knowledge) collectively produced, members of an organization craft their environment and collective frame of reference by selecting, rejecting and interpreting information. This frame provides routines informing the behaviour of members of the organization. Individuals thereby develop skills that favour the reproduction of the system and its stability over time. This frame endows an individual's actions with meaning, builds itself through interactions between members, and enables known problems to be solved. When the organizational environment changes and the routines no longer bring the desired results, organization members commit themselves to a process of destabilization followed by reconstruction. In unknown situations, the construction of meaning becomes intersubjective, drawing on individuals' behavioural and cognitive capacities and allows improvization. Then everybody can observe the effects and assess the advantages of adopting the behaviours and new cognitive schema produced. The change is a result of an experiential learning process (or learning by doing) as described by Kolb (1984). Argyris and Schön (1978, 1996) found complex retrospection mechanisms between individual and organizational learning. The changes in individuals' mental models to construct shared mental models of an organization modify the perception of the organization and transform organizational values and paradigms. Consequently, this modifies the environment of the individuals and affects their own mental models. In their studies of organizational learning, they note that organizations usually engage in first level experiential learning (single loop) to resolve short-term operational problems. At times, radical changes in the environment can lead organizations to enter second level learning (double loop). A fundamental reorientation of reference frames follows. This requires a redefinition of the organization's rationale and a new look at tacit knowledge, theories in use and espoused theories to analyse whether these are in tune with the new environmental situation.

Lave and Wenger (1999) show that the learning dynamics in communities of practice resemble those of organizational learning. However, in this case all of the members carry out the same tasks and have identical levels of experience. In addition, there is no central decision-making power such as that found in organizations where a leader plays a defining role in learning processes and group actions (Schein, 1985, 1988). The concept of multi-stakeholder platforms is interesting in the field of natural resources where interests are heterogeneous and indeed, competing. Aarts (1998) showed that in such situations, stakeholders tend to adopt negotiation positions that are strategic or conflictual rather than cooperative.

Chapter 4 showed that stakeholder groups are systematically constituted when a ComMod process is established. According to the definitions we just proposed, such groups are neither organizations nor practice groups but rather multi-stakeholder platforms. In ComMod platforms, the intention of the action, to draw participants into a learning situation, is clearly assumed and explained. By agreeing to take part in this type of process, participants show their willingness to interact, whether in a cooperative or conflictual manner. The conditions allowing an exchange between the mental models of individuals and the group, therefore, *a priori* are present. Consequently, can we apply the theories developed in the framework of structured organizations to ComMod platforms in order to explain individual and collective learning processes? To circumvent this methodological difficulty, we rely more on the concept of social learning derived from that of organizational learning.

Social or collaborative learning refers to the learning process of a set of people seeking to improve a situation through collective action. These groups may change and do not necessarily constitute organizations. The different definitions of social learning are drawn on the theory of communicative action (Habermas, 1984). They emphasize the role of dialogue and intercommunication between members of a group to facilitate the perception of different representations, development of collective reasoning and action. At first, this theory only referred to individual learning resulting from social interaction within a group and founded on the observation of the other (Bandura, 1977). It was then enriched by contributions on learning by Argyris and Schön (1978, 1996, 2002).

The concept of social learning was the basis for numerous approaches in the field of ecosystem governance aiming to increase a group's capacity to carry out joint activities linked to natural resource management (Daniels and Walter, 1996; Ison *et al.*, 2007; Pahl-Wostl *et al.*, 2008; Rist *et al.*, 2006). In these approaches, learning is based on interaction between numerous processes: the construction of networks and social activities, dialogue and communication around joint activities, the organization and management of knowledge. This learning is always situated. It links knowledge and relational practices to enable reciprocal interaction and discussion of these interactions. The urgency of the 'problem' (e.g. environmental, social, economic, etc.), and the interdependence between the stakeholders and their individual and collective stakes are the two main conditions that motivate stakeholders to involve themselves in social learning processes and collective action.

Numerous approaches rely on the development of various intermediary objects (Vinck, 1999) that have both a nominal function (because they serve to support the activity, give it meaning and promote exchanges of knowledge between participants), and an interpersonal function (they support communication, collective action and the

construction of networks). In the ComMod approach, these two functions often are assumed by simulations in role-playing games or through computerized models. These intermediary objects promote dialogue and understanding of other people's viewpoints. They help stakeholders to explore different scenarios of the future and to compare the costs and benefits of various management options.

Finally, the theories of experiential learning, organizational learning and its connection with social learning form a theoretical corpus. We have shown that this corpus allows interactions and mutual links between individual and collective learning to be taken into account. This corpus of knowledge thereby enables us to think about the learning of individuals and groups taking part in a ComMod process.

The dynamics of learning: a process or a result of change?

Now that we have described the link between individual and collective learning, we must examine learning modes. Is the concept of a learning dynamic relevant to ComMod? In other words, how does learning take place? In the literature, there is tension between two poles of thought: is learning the process that enables learning, the dynamic that enables the acquisition of knowledge, or is it a result of this process?

During the 1960s and 1970s, learning was defined in psychology as a change in behaviour, thus the result of a process. As such, it is tangible, visible, palpable and recognizable. This perception of learning is closely linked to the development of experimental approaches in psychology. The interest of this perception of learning is to show the characteristics of this result and thereby, to illustrate its relationship to the change. However, it does not take into account the factors that allow this behavioural change. Other authors consider learning more as a process, focusing on what happens when one learns. Maples and Webster (1980) considered learning to be 'a process that induces a change in behaviour following an experience'. The question then becomes whether the individual or organization is conscious of becoming engaged in a learning process. If so, what are the consequences of this state of consciousness on the learning process? We subscribe to the definition of learning given by Maples and Webster (1980), considering learning to be a conscious process. However, there is still the question about the conditions of learning within a ComMod approach. Placed in a given situation, individuals and groups acquire information that can lead them to change their behaviour and even their mental model.

Ramsden (1992) identified two types of learning. The first is outside the learner as it is provided by a third party, the teacher. This type is assimilated with the additional knowledge thus acquired. This knowledge is stored in a person's memory and is likely to guide their actions. It is translated into skills or methods so it can be called upon at any time. The second is interior, personal to the learner. It plays a role in his relationship with others and the world. It helps the learner to interpret and understand reality and to find meaning (Ramsden, 1992). A commodian does not focus his intervention on the teaching of knowledge but acts to promote exchanges of opinions and knowledge with local stakeholders. In doing so, he hopes to participate in the modification of the mental models of the participants in the ComMod process and also, through retrospection, of the groups to which they belong.

We should note some authors have emphasized that the advantage of working on learning processes is lost if it is not linked to an objective of action (Edelenbos, 2005; Röling, 2002). According to Röling (2002), collective cognition and distributed cognition

are two paths to achieving an action-oriented objective. 'Collective cognition emphasizes shared attributes, that is, shared myths or theories, shared values and collective action. Distributed cognition emphasizes different but complementary contributions that allow concerted action, for example, the operation of the market and legal frame of policies.'

This theoretical analysis indicates that individuals in organizations and less formal groups learn better in action situations, when they are confronted by a shared problem that they try to solve. The complexity, openness and uncertainty of the social and ecological systems studied do not allow an ideal solution to a given problem to be achieved. According to the theoretical analysis, the development of routines, the production of rules and the emergence of new interactions between group members appear primordial from the viewpoint of the learning expected from a ComMod process. To show the effectiveness of learning in a companion modelling approach, we focused our analysis on collective situations of interaction that occurred during a companion process. Learning will be understood at two levels of interaction, that is, that of the learner and that of the group. Based on the theoretical corpus made (with social learning, organizational learning and experiential learning theories), we aimed for a better identification of the types of learning and their associated dynamics in the different case studies.

Analysis of learning in ComMod experiments

We will now look at the material on which our analysis is based and the analytical grid we produced for a better understanding of learning in ComMod processes.

Contributions of the previous theoretical corpus to the construction of an analytical grid of learning in ComMod case studies

During a ComMod process a multi-stakeholder platform is built, and the theoretical corpus discussed previously allowed us to show that learning, produced through experience, is situated. Knowledge is a social construct, historically and culturally situated, and is ever-changing. Learning, individual and collective, is interdependent and dynamic, feeding each other through retrospection. There are two types of learning: single loop, where only the practices of individuals or groups are affected; and double loop, where individuals of a group recognize their own frames of reference and those of their interlocutors and bring them into question, which allows a more radical change. Lastly, the stakeholders involved recognize the urgency of the situation and their interdependence in order to be able jointly to address the question raised.

Recognition of multiple interdependencies occurs through processes of co-learning and interaction between stakeholders. These processes allow stakeholders to identify themselves and their interests and perspectives in relation to the situation studied, and give them certain legitimacy. These processes also define the frames of reference called upon and the conditions of their emergence. This work of mutual knowledge is helpful in understanding better oneself and others. It allows the broadening of one's vision of the world and the exercise (Aarts and Woerkum, 2002). Furthermore, learning about the relationship between individual and collective interests allows them to imagine together the desirable options by recognizing the costs and benefits that these solutions may have at the individual level (Checkland and Scholes, 1990).

Learning in ComMod thus must be understood at two interacting levels, that is, the learner and the group. This is because companion modelling approaches rally stakeholders who have heterogeneous frames of reference, interests and objectives to engage in a collaborative process on a natural resource management issue. Given the complexity, openness and uncertainty of the social and ecological systems studied, there are no ideal solutions. The resolution process puts into play strategic negotiation processes, including compromise and integrative negotiation. The latter require a true, mutual understanding and/or a creative process that promotes the redefinition of the objectives of the exchange.

The ComMod process systematically puts experiential learning to work. Companion modelling, particularly in role-playing games, places stakeholders in situations in which they may test, observe, represent their deductions and make operational. It follows, therefore, the Kolb cycle described above. The shared experience, based on principles of participation (i.e. universal right to speak, listen, interact, etc.) brings together stakeholders who would never or rarely meet or interact with each other, or who may even ignore the existence of their interactions and respective impacts on a resource that they nevertheless share. As the process proceeds, a feeling of belonging to a particular group is established that is based on these moments of exchange. The reflection organized at the end of the collective key moments (i.e. role-play debriefing, discussion-synthesis workshop) contributes to linking the experience, the opportunity to gain perspective on the actions and reactions of each, in the context of the real world. These processes of intersubjective communication take the form here of an exchange of experiences, arguments and clarification. It precedes the action, deliberate or improvised, that enables new management situations to be tested. To explain the reality of this learning, we have worked in particular on situations of collective interaction put into place during a companion process.

Beyond experiential learning, a transversal process in the ComMod approach, three other main types of learning are in play. These consist of learning about the content of the situation studied (nominal learning), learning about the participants and their interdependencies, and communicational learning. Given the wealth of material available, we chose a slightly more detailed analytical framework in which the first two points correspond to nominal learning.

– Learning related to the issue under consideration: general knowledge about the dynamics of the socio-ecological system, and the conditions in which the question addressed emerged.

– Learning knowledge and techniques that enable a better understanding of the technical options and their consequence on the socio-ecological system and its dynamics, and in this way think about the possible options that would allow the system to attain a desired state. This learning might involve the stakeholders as well as the research scientists involved in the process.

– Learning about others: on the one hand, this concerns knowledge of each actor's interests, skills and stakes; on the other, knowledge of the beliefs, viewpoints, norms and values of each actor.

– Communicational learning involves acquiring a mode of social interaction that permits the sharing of knowledge, learning and decision-making though experimentation with new means of communication. This point aims at the social learning of groups for collective decision-making, the mobilization of the stakeholders concerned, even the

most marginalized, the mobilization of key actors, and the creation of alliances to help the process advance.

– Organizational learning involves the acquisition of knowledge about the stakeholders' organizational options and their consequences on the system in order to select the organization that is most suited to achieving the desired system state. Selecting the organization means identifying the joint objective of all the members, defining the rules of existence, establishing routines and describing its hierarchy. This allows one to verify whether the ComMod process permits a multi-stakeholder platform to evolve into a true organization.

To correctly explain the evolution of learning during the companion modelling process, the learning dynamic must be broken down into three stages: (i) initialization and creation of a stakeholder group (creation of social ties and mutual confidence); (ii) dialogue and learning about the social and ecological system dynamic, the problems encountered and objectives sought, ways of resolving a problem and achieving an objective; (iii) the organization of stakeholders in order to achieve the objectives in the field. These different stages highlight the fact that the learning dynamic is part of a broader group dynamic in which the creation of confidence and the involvement of different stakeholders are essential.

Materials and method

The analysis is based on 14 evaluation reports produced through the ADD-ComMod project. The significant diversity of the case studies and the implementation modes of the evaluation protocol (Chapter 6) rendered the task delicate, particularly due to the absence of a firm definition of learning. Nevertheless, the wealth of material allowed a cross analysis of the evaluations. This was undertaken by comparing the views of two readers with those of the designers of the approach using the proposed analytical framework.

The analysis was complemented by monitoring collective key moments in each case study. There were different kinds of monitoring. Beyond monitoring certain collective key moments themselves, notably the game sessions by recording the actions and discussions of participants during the game and in the debriefing, some approaches specifically monitored learning. Methods varied between approaches; for example, there were individual, post-simulation surveys for analysing and understanding the actions and evolution of representations (Mae Salaep, Lingmuteychu), short pre- and post-game questionnaires (Camargue, AguAloca, Ter'aguas), and socio-anthropological monitoring (Njoobaari). These elements are particularly important in reporting learning dynamics.

Each type of learning is present in the quasi-totality of the case studies. Their combinations vary chronologically, qualitatively and quantitatively. We propose to to illustrate by concentrating on each type using one or several case studies that benefited from close monitoring at the time of implementation.

Learning in ComMod experiments

Learning about the issue addressed

All of the evaluation reports mentioned that whatever a participant's involvement in the companion modelling approach may be, the participant leaves with a greater understanding of the complexity of the stakes and the dynamics of the issue addressed. One witnessed during the process an accumulation, interaction, production of knowledge,

information and multiple and varied data contributed by the ensemble of participants in the experiment. This more or less powerful awakening to the complexity of the system studied (some may have already been sensitized before the process, others not at all) was demonstrated by the specification of a wide variety of practices, representations and perceptions of the goal and subject of the study.

The AguAloca study case (see the Appendix) is particularly illustrative of this type of learning. It aimed to facilitate consultation processes regarding the multi-use management[2] of water resources in a watershed committee in the metropolitan Sao Paolo region in Brazil (Clavel *et al.*, 2008). After a series of thematic studies aimed at better understanding the dynamics of the watershed, a computerized role-playing game called AguAloca was developed in a companion modelling process mobilizing a multi-disciplinary team and a small group of managers. The game itself was played twice, the first time with engineers from different institutions (i.e. potable water supply company, water management department) and representatives of several towns, and the second time with several members of the watershed agency of which the committee was part. Each game session was monitored by: (i) two people who observed the development of the game and the individual and collective behaviour of players; (ii) two short questionnaires completed by players before and after the game to analyse their expectations, feelings about a session, and the evolution of representations of the management issues. An evaluation was carried out through semi-structured interviews nearly eight months after the last game session with the players and actors who participated in the design.

Participants emphasized the contribution of the ComMod process in terms of understanding the overall issues, notably the significance of the terms 'integrated or shared water management' and 'collective action for water management', which were the two main principles on which the committee's work theoretically was based. Participants emphasized the highlighting of underlying interactions between different activities and processes on the watershed, as well as the interdependencies between actors, and between decisions, resources and actors. One player noted an accelerated learning about watershed management issues, learning usually acquired only after participating for two years in committee meetings – this, when the mandate for representation only lasts two years. The 'local' perspective of each stakeholder was articulated to produce a shared representation of the issue addressed and the stakes involved. One person mentioned that the game served as a reference framework to understand and analyse committee discussions. The testing of the model allowed the issue to be appropriated, which resulted in the transformation of how participants grasped questions. For example, technicians who initially were principally concerned by water quantities began to think about the qualitative processes highlighted by the game experiments. Specialists were called in to explain their research results and a workshop was organized by the committee on the subject.

Learning about others

All of the evaluations emphasized the stakeholders' learning about others. This learning focused on both a better understanding of each actor's interests, skills and stakes and on building an awareness of their beliefs, viewpoints, norms and values. The inter-

[2] Drinking water for the agglomeration, industrial use, agricultural use, dilution of sewage, flood protection and recreational use of reservoirs.

views undertaken in the AguAloca case study highlighted, beyond learning about the issue discussed above, the better understanding of the various watershed stakeholders' interests, practices and their impacts on the resource. Participants realized that they were all legitimate, concerned and dependent on each other, and that they had to work together and 'accommodate each other'. Participants particularly appreciated the possibility of testing other stakeholders' management difficulties, leading some to develop a greater capacity to listen and take into account the contributions of others during committee debates.

The Lingmuteychu case study (see the Appendix) illustrates another aspect of this type of learning. On the Lingmuteychu watershed in western Bhutan, seven villages share water from different rivers for domestic use and agriculture irrigation. The principal crop is high altitude (over 2000 m) rice grown on rain-fed terraces. The availability of water during the brief transplanting period is the main factor limiting yields. Terraced fields must be completely flooded sufficiently early in the year for transplantation to avoid a failed crop because rice flowers when temperatures are low. Numerous conflicts had arisen between the communities on the watershed over this issue. In 2002, there was a dispute between two villages, one downstream of the other, over the opening date of the principal floodgate of the downstream village's irrigation system located on the territory of the upstream village.

In this context, a scientist from the Bhutanese Bajo research centre began a ComMod process with participants from the two villages that took the form of three, three-day workshops in 2002 and 2005. Each workshop was organized around a role-playing game session in which the relationship between irrigation and cropping was acted out. These games did not refer to either the floodgate or the opening date but emphasized communication between and within communities. At the end of the second workshop, it was decided to include all seven villages on the watershed in the game. The evaluation of the ComMod process was based on three series of semi-structured individual interviews and on the participatory observation of a training session on collective action that the Bajo research centre organized on behalf of the watershed natural resource management committee. Of the 11 participants from the downstream villages that were interviewed, only one claimed to have understood something about the conflict in which he was involved. In contrast, six of them claimed to have learned about a conflict between two other villages on the watershed in which they were not involved. These six participants could explain the conflict and formulate advice for its resolution. Observations of other participants, discussions and debates that took place during the three days of the final workshop enabled them to acquire knowledge of the issues, positions defended, power relations and obstacle points. Based on this observation, the formulation of advice reflected the reflexive character of the exercise and a conceptualization of the information collected. The interviews, however, did not clarify how the learning process continued after the workshop, notably whether it was individual or collective.

Learning about others was particularly strong in the companion process that took place in the Vendres tidal area (see the Camargue case study description in the Appendix). This humid, 1600 hectare area situated in southern France includes nearly 900 hectares of reedbeds. The area has a high heritage value, notably for waterfowl, and is the object of multiple uses, that is, grazing, hunting, fishing and tourism. In response to the generalized degradation of the environment due to numerous conflicts of interest, a coordinated

management plan was implemented starting in 2003 by the Syndicat mixte de la basse vallée de l'Aude (SMBVA). ButorStar (Mathevet *et al.*, 2007), a role-playing game, served as a mediator in user discussions on the collective management of the tidal area. Two role-playing sessions were organized in 2006 by SMBVA with 12 users (Mathevet *et al.*, 2008). The experiment was expected to enable discussion of the technical, social, economic and environmental stakes involved in the management of a humid zone. The evaluation was carried out based on individual questionnaires before and after the role-playing game, followed by a telephone interview three to five weeks later. The evaluation was completed one year later by a series of semi-structured interviews with players and organizers. The users' understanding of the effects of water management clearly had improved, as well as the impact of human activities, particularly those related to cutting and grazing, on the ecological evolution of reedbeds and on avifauna (Mathevet *et al.*, 2008). Two-thirds of the players said they had learned a considerable amount about the effects of user practices on other users, and particularly about the needs of other actors. All of the participants emphasized the importance of sharing knowledge. For two-thirds of them, the experience had not significantly modified the way they viewed how the tidal area functioned. However, they said it had helped them discover the importance of considering the impact the environment had on human relationships and vice versa. After three weeks, they unanimously considered the experience to have improved their capacity to participate in group projects on the management and development of nature areas. One year later, the survey through semi-structured interviews revealed that the lasting value of some of this learning had diminished. Notwithstanding, the survey showed that all of the users were interested in renewing the experience.

Learning technical knowledge

In the majority of the evaluations, the stakeholders who participated in the companion modelling process declared that they had acquired technical knowledge about the structure, dynamics and functioning of the system studied. The diversity of knowledge acquired obviously is linked to the situations dealt with by the projects. This ranges from knowledge acquired through specific training, particularly in mapping, to a broader understanding of farming strategies, agricultural, forestry and pastoral dynamics, interactions between societies and resources, the role of certain economic regulatory tools (e.g. water management fees), interactions between agricultural and urban activities (e.g. risk of fires, urban sprawl on to farmland), and even procedures to implement new management mechanisms and their potential consequences on agricultural practices.

In the Lingmuteychu case study, several inhabitants of the downstream village began agronomic experiments following the first workshop, introducing a second crop (carrots, potatoes, turnips) before the rice crop in their cropping systems. This initiative was referred to several times as a result of the workshop. Asked about their experiments, the farmers explained that they decided to carry them out when they noticed during the role-playing game that such activities had an impact on the income of people practising it in the upstream village. Discussions took place between participants from the two villages that enabled a transfer of technical information. The diffusion of this technical innovation is a horizontal knowledge transfer, from one participant to another. The workshop served to stimulate this learning without actually supplying the corresponding technical information. Once the learning cycle was initiated, the interested participants collected

technical information directly from the pioneering farmers. This learning was made possible by the discovery of the principles and results of double cropping practised in the upstream village. It illustrated learning about farming activities in other villages. The habitants of Dompola already knew that their neighbours had recently begun to cultivate potatoes before the rice crop but they had not copied this potentially lucrative practice. Role-playing games, particularly when the roles between the two villages were inversed, contributed to increasing their knowledge of the others' activities and economic results.

The Lam Dome Yai case study (see the Appendix) is a good illustration of another type of technical learning. This work aimed to deepen knowledge about the interaction between water use, management of labour and land and migratory flows in three different types of non-irrigated, family rice farms. At a time when the Thai government was planning a new wave of sophisticated and expensive hydraulic installations, the plan was to test a hypothesis that a greater availability of agricultural water would limit the extent of worker migration, the condition required for the sizeable planned investments to be profitable. Between 2006 and 2008, a series of round trips between the field and research laboratory enabled the co-construction of a MAS simulator. This work was punctuated by five workshops based first on role-playing games, and later on participatory computer simulations. These workshops grouped together students and teachers, agricultural workers, and rice farmers and their families working 11 different kinds of farms. The sustained monitoring and evaluation of the effects of this process were undertaken through participatory observations, systematic individual interviews following each collective key moment and a recording of life histories. While the types of learning are again diverse, this evaluation demonstrated particularly interesting results regarding technical learning. The rice farmers declared that they realized that they needed to be better organized in order to manage better the risk of drought on their farms. On the one hand, the experiment had led them to envisage previously unimagined situations and, on the other, to gain a better understanding of the relationship between water availability, migration and a lack of manual labour on small and medium-size farms. The arrival of an irrigation canal or a large community basin would increase agricultural incomes and allow the introduction of 'integrated systems' (i.e. planting several types of crop around an aquaculture basin also serving cattle livestock and adjacent rice fields). The improvement of knowledge concerning the relationship between the distribution of rainfall and the rice farming calendar was reflected particularly in a better understanding of risk-avoidance strategies for transplanting rainfed rice. In this way, numerous small and medium-size rice farmers declared that following their participation in the workshops they had changed the way they decided their agricultural calendar, varietal choices, use of water from their individual basins, and allocation of manual labour on their farms. One of them had undertaken work meant to supply him with more agricultural water. Lastly, the participants considered that they had acquired new knowledge about how to manage a community basin.

Communication learning

One of the fundamental principles of the companion modelling approach is to consider and facilitate the expression of different viewpoints about the social and ecological systems studied. The participants gathered together consequently are heterogeneous. This heterogeneity is of various orders (e.g. social, economic, disciplinary), and

regroups people of different status (e.g. individuals, representatives of one or several groups, scientists, members of the civil society or simply an inhabitant and citizen). Given this diversity, communication learning is thus a major challenge in the participatory approach. In addition, the analysis of evaluation reports showed that communication learning facilitates the autonomy of participants in terms of their participation in various group processes, from exchanging information to consultation and indeed negotiation. Participants' increased autonomy also relates to a change in the relationship between stakeholders and research scientists. Numerous research scientists recognized that their attentiveness to others was modified through their direct interaction with stakeholders. Numerous case studies showed that participants not only acquired an assurance that enabled them to speak more freely and express their viewpoints, they also learned to accept both that other people may hold different representations than their own and to question the hypothesises of others. Collective key moments were recognized as being particularly propitious for more equal and less hierarchical exchanges compared with that which occurs in more traditional systems of interaction.

From the viewpoint of the organization and the analysis of collective actions, some companion modelling experiments enabled a better identification of the difficulties of certain functions within organizations. These experiments also permitted knowledge to be acquired about the modes of functioning and the attitudes of those in charge, as well as their own attitudes regarding other hierarchical levels. This was notably the case in the Ter'aguas study (see the Appendix). This experiment focused on reinforcing the negotiation capacities of community leaders in the Sao Paulo metropolitan region of Brazil to facilitate their participation in collective decisions regarding complex questions of joint management of water and land in the peri-urban zone. In discussion platforms, their involvement remained limited by sharp social inequality, asymmetric information, a lack of training, a hierarchical distribution of power with other stakeholders and competition between leaders. In addition, the authorities' strong tradition of paternalism encouraged a wait-and-see attitude and patronage cultivated by the opportunist, short-term strategies of local politicians.

The process was developed in two stages: the first stage was dedicated to the collective development of different tools[3] that would facilitate discussions on different aspects of the issue and accompany the reconstruction process. The second stage, inspired by the ARDI method (Chapter 3), relied on several activities and tools developed during the preceding stage. Several workshops were held, including an organized session on a computerized role-playing game gathering community representatives and public authorities (principally from the water authority and the municipal government). This role-playing game, named Ter'aguas, permitted the simulation of collective decision-making processes and the visualization of their impact on the region. This process was tested twice: to support the preparation of a municipal master plan in the north of the Embu-Guaçu region and to help resolve a conflict between three communities, the mayor's office and the water company over a sanitation project in the Paralheilos region (Sao Paulo municipality). Each game session was subject to monitoring and evaluation

[3] Computerized and non-computerized role-playing games, a basic drawing to permit the mapping of subdivisions' 'resources' and a dramatization of a conflict over a development issue in a subdivision (without representing biophysical dynamics).

by game observation and two short questionnaires completed by players before and after the game. The evaluation was carried out nearly eight months after the last workshop. Of the approximately 35 participants from the two workshops, 24 (leaders and government representatives) were interviewed.

After the game session, the evaluation on the first site immediately noted learning about negotiation mechanisms, particularly the notion of mutual benefit, diversity of stakeholders' interests, advantage of a proactive attitude and the need to take into account the set of issues at stake in the discussion of solutions. Other learning also was mentioned (e.g. on the issues, technical aspects and interdependencies), but they tended to diminish in the long-term evaluation. Participants recognized that having taken part in the entire process encouraged them to think about how to interact with other stakeholders. They particularly became aware of the need to organize better and articulate their expectations, and to become more engaged in a process of dialogue rather than complaining to authorities. Participants mentioned a change in the way they interacted with people in their daily work, notably being more open to listening.

On the second site, interviews after the game session emphasized a new interest in seeking collective solutions, such as a partnership between the water company and municipal government. By freeing participants from habits and conventions, the game allowed them to explore this previously unthinkable type of alternative. Stakeholders declared that participating in a companion modelling process helped them think about the ways they interacted and about how to build collective solutions. They emphasized the light the process threw on to various stakeholders' attitudes in discussions and the different negotiation techniques used. The game also enabled different stakeholders to be brought together, but the stakeholders remained conscious of the specific character of this rapprochement: on the one hand, the cooperative character of the exchanges was very different from the more conflictual and tense traditional forms of interaction; on the other, community leaders rarely have such easy access to public authorities. In the long term, the learning noted shifted to communication and interpersonal aspects even though a better understanding of the issues at stake and the complexity of the situation were still mentioned by some. Community leaders emphasized the acquisition of interpersonal skills, such as taking a position in relation to other stakeholders, involvement and engagement in the analysis of different aspects of an issue, and the need to articulate better and defend their viewpoint. The search for a solution was now seen as a process that involved different steps and stakeholders and required a preliminary search for, and use of, information. Representations of modes of interaction were modified. The most active leaders were also led to rethink their role in relation to their association or community, or the advantage of individual action (of leaders) in relation to community needs. However, while these representations clearly had evolved, few concrete changes in practices were noted. The leaders' stance in relation to inhabitants, inspired strongly by the prevailing thought that the disadvantaged members of the population needed to be educated, did not seem to have changed. Institutional actors mentioned, however, a greater ability to listen to communities and an increased awareness of local stakeholders' viewpoints when working on solutions.

Organizational learning

The evaluation of the Lingmuteychu case study more specifically highlighted the organizational learning that followed the last workshop where it was decided to

institutionalize a committee to manage the natural resources of the watershed. This institutionalization was made possible by the involvement of institutional representatives in the process and by the emergency context that promoted the formalization of the results of the ComMod process. For example, certain results were integrated into the statutes of the watershed management committee that was created six months after the final workshop. Funding was sought with the help of the research and development service in order to implement without further delay the first collectively defined action plan (e.g. restoration of canals, community plantations, etc.). This rapid implementation of collectively approved actions thus helped to reinforce the legitimacy of the newly created institution. A calendar of quarterly meetings permitted the monitoring of activities, the adaptation of their planning and the maintenance of a cooperation arena at the scale of the watershed.

The Méjan case study (see the Appendix) also illustrates the organizational learning of stakeholders. Located in the Parc National des Cévennes in southern France, Causse Méjan constitutes one of the last high steppes of western Europe. Current grasslands are the result of efforts over several centuries to develop grazing and agriculture. This agro-pastoral development has resulted in a decrease of natural forests. Beginning in the 1970s, the national forestry policy promoted the afforestation of certain sectors of the Causse with Austrian black pines. The sexual maturity of these afforestations extremely accelerated reforestation through the spontaneous encroachment of the pine trees and worried national park workers. The ComMod process was initiated with all of the concerned scientific department members and field agents. A simulation model was built based on the available literature and field agents' knowledge to understand the overall functioning of the site (Étienne *et al.*, 2003). The simulation tool then was used as such or in the form of a role-playing game to discuss collectively the probable dynamics of the pine trees with farmers, forestry agents and national park workers (Étienne and Le Page, 2004).

Simulations of scenarios and role-playing sessions allowed livestock breeders, farmers, forestry agents and national park workers to discuss and acknowledge the future pine tree encroachment process. The ComMod process led to the implementation of a joint local development plan enabling the collective protection of open areas from reforestation. Simulations emphasized the importance of grouping neighbouring farmers to define a united strategy before developing contracts. They also showed the advantage of taking a long-term perspective and to start planning activities to continue after the end of the local plan. This last point resulted in establishing contracts between 28 farmers, the national park and some forest estate owners. However, while the experience allowed concrete organizational learning, structural obstacles persisted impeding the adoption of new practices and a shared strategy to prevent the spread of pine forests. The evolution of agricultural practices on the Causse remains subject to economic realities and the vested interests of agricultural and forestry sectors. As a matter of practice, livestock farmers claimed financial aid to accompany change. A lack of synergy between public stakeholders due to political or institutional reasons did not allow a continuation of the local development plan when funding ended in 2004.

Learning dynamics during a companion modelling process

In a consultation process, the various types of learning described above combine in a dynamic and progressive manner so that stakeholders with different perceptions and

interests are able to hold dialogues, understand each other better, and even reach an agreement on certain points. While there is little information on learning dynamics in the evaluations, it generally seems that this dynamic is linked to the manner that collective key moments of exchanging viewpoints are alternated with periods of more individual reflection, periods during which participants of the ComMod process may be in contact with other stakeholders and other participatory or non-participatory processes.

The Mae Salaep case study (see the Appendix) in the north of Thailand illustrates such a learning dynamic in a consultation process regarding a conflict over access to irrigation water between different types of farmers in a village community. In this village, gravity irrigation through canals capturing brook water was introduced in the early 1990s with the establishment of litchi plantations. The first planters (the wealthiest farmers) then established the rule 'first come, first served': when a farmer set up an intake on a brook, no one else had the right to place his own intake further upstream. Only a few farmers thus had access to water, and the recent increase in the number of those desiring irrigation resulted in rising tensions within the village. This was the context in which a ComMod process was implemented focusing on the water issue.

During the first game session, the players' actions highlighted the water issue, which created an awareness of the need to collectively resolve this problem (learning about the issue). 'The game enabled the players to understand on their own that it is necessary to change the current rules without our telling them so.' This declaration by a village leader illustrated the experimental nature (as defined by Kolb) of the type of learning in evidence here. Furthermore, through its interactive role-play, the game allowed different participants to gain a better understanding of the situations, problems and perceptions of other stakeholders regarding the water issue. This may at first seem surprising as the members of this small community of a 100 families all know each other. However, as one of the participants said about the game: 'In daily life, everyone goes into the fields. We don't have such an opportunity like this to discuss our problems.'

During the debriefing following the first game session, participants discussed the nature of the problem. In a consultation process, the collective reformulation of a problem is a key step because it determines the manner in which the group will seek a solution. It involves a kind of collective learning about an issue that is related to the collective representations of the issue. In the Mae Salaep case, the following question was asked: is the problem one of availability (water shortage) or of appropriation (unequal distribution of water)? The idea finally chosen by the participants was one put forward by a religious leader in the village. Aware that it was impossible to question directly the 'first come, first served' rule (the local elite would never accept this), he expressed the idea that the problem was linked to a lack of water and suggested constructing a hill reservoir for each village brook in order to increase the overall amount of water available. This would provide an opportunity to discuss rules on how to share water between the beneficiaries of each reservoir. 'Without new installations, the rules will not change' this leader said after the workshop.

Participatory simulation sessions using a multi-agent computer model enabled participants to collectively consider what rules could be implemented if such hill reservoirs were constructed. The type of learning used at this stage corresponds to learning about collective organization. During the workshop, a wealthy farmer imposed the idea that the allocation of water should be based on the surface area planted with perennial crops to be

irrigated. Three weeks later, however, participants who had continued to discuss the issue reached an agreement on a more equitable form of sharing. Small farmers without access to water thus were gradually able to make their position heard in the consultation, not only through a reinforcement of their individual capacities (e.g. self-confidence, better understanding of the stakes), but also by reinforcing their collective position through the creation of a coalition around a charismatic leader. This corresponds to communicational learning linked to stakeholder networking.

Co-learning between scientists and stakeholders

Thus far, we have focused on presenting learning from the viewpoint of non-scientific participants. Yet the principles of companion modelling emphasize that the research scientist is himself a participant in the process. As such, he may learn from his intervention like everyone else. In reality, the research scientists acquired knowledge about the social and ecological systems studied in all of the examples presented. More specifically, the commodians improved their skills as far as the facilitation of the companion modelling process and the contextual limits of the ComMod process were concerned.

We considered the example of the Njoobaari case study (see the Appendix). This was one of the first companion modelling experiments, conducted between 1995 and 2003. The work was undertaken in two irrigated systems in the Senegal river valley. Since the 1980s, agricultural irrigation policy based on constructing expensive hydro-agricultural installations to overcome this Sahelian zone's climatic constraints had proven to be a failure. A preliminary investigation was carried out to understand the technical aspects of water management in the framework of a water science thesis (Barreteau, 1998; Barreteau *et al.*, 2001). From the field analyses, it appeared that the issue at stake was related less to the quantity of water resources than to the coordination between stakeholders in the irrigated system, from managers up to farmers. A simulator was built to understand how the system operated and to test different combinations of parameters that could facilitate assessments of the viability of an irrigated system. A role-playing game was developed to assist farmers to learn elements of the computerized simulator and discuss the parameters. The farmers' and managers' interest in this tool led the designers to use this role-playing game to help farmers think about their management of water and the credit required to cultivate their plots. A second thesis was undertaken between 2000 and 2003 aiming to analyse the relevance of this type of tool in consultations (Daré, 2005; Daré and Barreteau, 2003). The use of role-playing games enabled farmers to share the diversity of challenges that they faced to cultivate on the irrigated scheme, to realize and discuss the impact of some people's unpaid loans on the entire group's access to credit (joint surety credit), and to promote exchanges outside the highly codified, customary arenas. From the viewpoint of research scientists, in addition to sociological surveys to obtain a better understanding of the social systems, the role-playing game was validated not only as a pertinent discussion support, but also as a social investigation tool able to acknowledge the complexity of the system through the analysis of stakeholder interactions in the game and in reality. The methodological results of the analysis and the tools produced served as a basis for other case studies in irrigated systems in Asia and Latin America.

Beyond exploring the diversity of the situations studied, this first analysis of learning in ComMod approaches highlights a common core: learning about the issues at stake and interdependencies, rationalization of various types of knowledge, including both

scientific and local know-how, the emergence of new forms of knowledge in the form of technical or socio-organizational solutions, and communicational and organizational learning. These types of learning overlap closely, as do individual and collective learning. This work constituted a first step leading to the recognition of the relevance of our hypothesis regarding the learning process induced by participation in a companion modelling approach. However, some questions remain.

Towards perfecting the approach to consolidate learning

Improving the survey framework

Untangling the web of learning is not easy due to a lack of specificity in the questionnaire used for this analysis. The framework used, together with the theoretical analysis of learning, proved to be relevant when taking into account the diversity of the learning observed. However, the challenge was to maintain coherence between the expectations of companion modelling and the types of learning that we wished to monitor and evaluate. In the ComMod Charter, companion modelling is presented more as a mediation approach between individuals, groups and knowledge than a production process of technical knowledge in the strict sense of the word. This does not mean that there is no learning of knowledge or technical skills. For example, in the case of Mae Salaep, the evaluation of learning revealed that farmers had thought about technical aspects, at times beyond what was expected given the activities undertaken. The evaluator revealed a link between the companion approach and the adoption of erosion control techniques among some farmers although this theme had not been addressed directly in any of the three successive cycles. A more detailed analysis highlighted that this learning was the result of interactions between participants following the first workshop, but the learning was attributed directly to the ComMod process by the farmer(s) interviewed. Thus, even when the ComMod process does not emphasize technical aspects, 'seeds of reflection' are sown through the interactions, consciously or unconsciously, and, in certain individuals, will find a favourable field to sprout and grow. This occurs as if the setting of a scene and the participation in a concrete experience, even if partially virtual, had initiated a Kolb learning cycle in other places and at other times on subjects that may have nothing to do with the designer's intentions. We see here the importance of learning about others, which creates the confidence, habit of exchange and sense of 'between-ness' that facilitates future interactions between participants in a ComMod approach. However, from the viewpoint of research, how should one take into account these seedlings that may have been unconsciously sown yet still have an impact on the process?

In our analytical framework, we also tried to distinguish the results of learning (what we learn) from the process itself (how we learn). This differentiation results not only from putting theory into practice, but above all, the need to improve the learning process within the ComMod approach. While learning techniques like role-playing games or collective key moments are heartily endorsed by all participants, we are not prepared actually to take into account the learning dynamics that punctuate the process. To be able to do so, should we follow the example of educationalists and break down the expected learning in such a way that each element is clarified and examined in the light of the effective stages of the process? In processes addressing situations that are by definition complex, based

on interactions between actors and the environment, is it possible to undertake such a breakdown without over simplifying the learning and hiding the complex nature of the systems studied?

Learning that is individual and collective or individual learning of a collective group

The analysis of the material collected showed that some types of learning are particular to individuals and other types to groups. However, as long as learning remains in the field of cognition and does not result in action, it is difficult to distinguish between the two levels. Most of the other types of learning, realized in action, are quite often the result of interactions between individuals or between members of a group. With experience, one understands better the paradox of organizational learning raised by Argyris and Schön (2002)[4]. Finally, these types of learning that we have described as being individual are part of individual learning that is acquired collectively, thus drawing close to distributed cognition of learning between group members.

Yet in the companion modelling approach, group learning is essential. One difficulty in the learning realized though multi-actor platforms, in contrast to existing organizations, lies in the need to first establish a common objective. Some social learning approaches favour double loop learning, which requires excellent communication skills, while others prefer to consolidate social ties and create a sense of engagement by mobilizing participants around a desired future. When participants reach an agreement on an overall objective, experiential learning processes may take place and skills may be reinforced. This result is compatible with the work of Callon and Latour (1981), which rejected the possibility of separating these two dimensions. The actor-network concept introduces an analytical framework in which technical and sociological components are intimately linked in the same network. By observing how a Swedish compacting machine was adapted to brick production from agricultural residues in Nicaragua, Akrich (1989) highlighted the successive, back and forth movement between technical innovation, social evolution and biophysical environmental transformation.

The monitoring of learning in the case studies showed that it is possible to identify a joint group objective during collective key moments in a ComMod approach through the exchange of experiences and the exploration of scenarios. This is easier than relying on double loop learning based on methods such as Socratic dialogue techniques. Once an acceptable common objective or scenario is defined, each participant is able to readjust their own initial objectives. Participants may thus engage in a process of seeking information and technical and organizational options that would enable the achievement of collective and individual objectives.

We must equip ourselves, therefore, with the means, not only to take into account other types of individual learning, but also to promote them when necessary. The question then becomes how shall collective learning be reinforced when this proves to be necessary? Should we try to seek the involvement of local organizations (which touches on the power struggle issue discussed in Chapter 5) more systematically, or should we seek to render the groups constituted through a ComMod process more enduring (which raises the question of their legitimacy or their legitimization in the local context)?

[4] For some, an organization has neither a mental model nor a memory, and thus cannot learn.

From learning to action and social change

This last question brings up the issue of the future of the companion modelling process once the commodian has left the study site and thus, of how the learning achieved is perpetuated. How shall one capitalize on the positive dynamics produced during moments that are highly collective but limited in length? Some case studies implemented a specific monitoring process of collective key moments. The learning was re-evaluated *ex post facto* through the ADD-ComMod project several months and even years later. This monitoring over time allowed us to take into account learning dynamics. What emerged is that little of the learning led to effective change in practices or to concrete action able to initiate more profound social change. The achievement of an Argyris and Schön double loop was not easy and undoubtedly is one of the main issues on which commodians must continue to work.

One avenue to explore is the more systematic involvement in the approaches of local partners (e.g. local NGOs, development organizations, village intermediaries), who would be able to assume the process on their own account, to perpetuate results of group discussions and to translate them into concrete actions integrated into development programmes. The training of commodian apprentices would be necessary for such a long-term effort.

Some tools and methods derived from ComMod approaches can be used to consolidate learning. Role-playing games are powerful instruments that enable players to take into account the diversity of interests at play. This can be done even when the game takes the form of a simple social drama, a dramatization of roles that does not involve interaction with an environment (Camargo *et al.*, 2007). For instance, in the SosteniCAP case study (see the Appendix), a role-playing game was associated with a set of activities aiming for legal restructuring and consolidation of community potable water associations. The role-playing game where the economic operations of these associations were represented enabled learning on how to operate and reinforce social control within certain associations. The relevance of these tools is linked to their participatory development. This participatory development enables the integration of different representations into a flexible approach capable of adapting to local specificities. Some tools produced by development approaches may also be used in ComMod approaches to support certain stages or to prepare the integration of results in collective, action-orientated processes.

However, authors such as Jiggins and Röling (2000) questioned the capacity of social learning approaches to move past socio-political differences, power plays and conflicts. Facilitators of these approaches may be led to support an empowerment process for some participants, or more strategic negotiations, and to mobilize themselves to execute the agreements negotiated (Leeuwis, 2004). During the 1980s, gender-related literature showed that women needed first to be made aware of the problem under consideration and of their role, and to share their experiences between themselves, before they were able to participate in discussions involving a wider audience. Womens' groups offer the possibility of exchanging experiences, acquiring knowledge about the issues at stake, understanding different interests, developing communication skills and reinforcing self-confidence prior to receiving support enabling them to engage in negotiations with other stakeholders. Preliminary work with hybrid simulations within homogeneous groups (and not platforms of heterogeneous stakeholders), as in the Mae Salaep case study, can thus allow the same type of learning, which is crucial for an equitable consultation process.

For learning to endure, the institutionalization of results, or, in other words, irreversibly anchoring these results by relying on locally legitimate constraint systems, whatever their form, appears indispensable, as was highlighted in the Lingmuteychu case study. However, this institutionalization is not problem-free: it assumes an organization with development partners that is achieved sufficiently early for the latter to feel like stakeholders in the approach rather than instrumentalized by it. Furthermore, the institutions mobilized must be able to intervene with the flexibility needed to integrate propositions that may take unpredictable and relatively heterodox forms. The structure and orientation of development projects does not necessarily allow such flexibility.

It seems that the passage from learning to collective action is in large part dependent on the context. If the context is not mature, if the protagonists do not feel an urgent need to act, if their room to manoeuvre is too limited, then learning risks becoming diluted over time. Does this mean that to result in concrete action, modelling approaches should only be developed in contexts marked by tension? A review of the various case studies (Chapter 4) indicated that such a short cut would be a mistake. The passage to action can be prepared. However, this requires thinking about how to prolong the duration of the ComMod approach after the project ends and how to diffuse results from the very beginning of the project.

How can we proceed towards the production of skills/knowledge/capacities that can be transferred to people outside the process? What method should be put in place to further the diffusion of knowledge? If one works from the perspective of situation learning, Wenger (1998) and Loeber (2003) have shown the depth of difficulty in trying to extrapolate beyond the initial group. The perspectives and engagements resulting from a social learning process reveal themselves to be, in effect, difficult to transfer as much to all members of the social group represented as to the regulators and decision-makers, particularly when they result from intense interactions. Those initiating projects often neglect the importance of pre-existing institutional rules and power dynamics (Chapters 4 and 5). Henceforth, it is accepted that no matter what the context, facilitators and participants need to position themselves in relation to socio-political discourse and dynamics. Ignoring this socio-political context raises the risk of widening the gap between the solutions that are locally desired and those that actually are implemented. Furthermore, this discussion on the passage from learning to action, and the initialization of social change, should be debated again in terms of the various stances of research scientists (Chapter 5) and the development of a quality approach (Chapter 8).

From a virtual world to reality

Collective key moments are special, concrete experiences during which the essentials of learning occur or are initiated. Chapters 3 and 7 showed the power of the intermediate objects used to put stakeholders into situations favouring interaction, allowing them to exchange viewpoints and to construct a shared representation of the issue addressed. However distant the description of the world in role-playing game sessions may be from the real world, certain stakeholders will apply the learning obtained during the game session directly to their daily life. The danger is particularly real in relation to technical learning, particularly where there is an outreach and villagers support mechanism for technical advice. In interviews for the Thai case study, numerous farmers said: 'I will do as the game showed me because then my income will increase'. This kind of pitfall

is dangerous as the simulations only represent a simplified vision of reality. Considering the level of simplification in co-constructed models, commodians must take special care to prevent this lapse. The game is not reality (Daré, 2005). It is a moment apart that allows discussion about reality but the learning that occurs in the game is not a toolkit that can be transposed intact to reality. More in keeping with the ComMod stance, others declared that: 'it made me think about this technical solution that I had not considered before'. The translation, deconstruction-reconstruction of learning, and adhering to the principle of reflection must guide the actions of the commodians. It thus might be fruitful to link the ComMod approach with technical services more capable of transforming the technical learning acquired during the games into valid learning for the reality of farm management, to name one example.

Conclusion

Social learning processes traditionally opt for two types of objectives: (i) reinforcing social ties through an engagement around a desirable future; (ii) double loop learning allowing the individuals' mental representations to be reconsidered. This presumes that the capacities of comprehension, questioning, debate and reflection would be mobilized to highlight tacit knowledge and create a real forum for exchange. The ComMod approach aims for both types of objective. On the one hand, it facilitates the identification of a shared, desired objective through the development of scenarios that can be tested and discussed. On the other, it allows the development of interpersonal and communication skills. Collective key moments occupy a crucial place in this learning, whether individual or collective, because they provide an occasion to explore interdependencies during debates over the construction and evaluation of scenarios.

The companion modelling approach, therefore, appears to be an interesting way to promote a certain amount of conscious learning likely to engage a heterogeneous group in actions permitting more sustainable development. It introduces ways of sharing knowledge, learning and decisions that are innovative for most participants. Commodians effectively incite participants to involve themselves and experiment with new forms of communication based on interactions between stakeholders and between stakeholders and systems, which facilitate learning by experience. These exchanges simultaneously allow learning about the challenges and emerging issues in all their complexity and a better understanding of others and their interests while clarifying the reference frameworks of each. This promotes the reconsideration of these various elements, a prerequisite for discussion and experimentation, and the learning of new technical, organizational and communication rules.

However, the learning dynamics in the ComMod processes deserve to be described better. At the close of our analysis, new questions appear that should lead to more precision on the phenomena of learning in ComMod approaches, notably the passage between virtual and real worlds, the latter of which is by definition more complex, regarding the capitalization of this learning and its diffusion within and beyond the group to decision-makers, and the transformation of learning into individual and collective practices.