Intermediate concepts in the generative dance between knowledge and knowing

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The notion of "intermediary concepts" contributes to a better understanding of the generative dance between knowledge and knowing

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Recognizing and facilitating the generative dance between knowledge and knowing is essential and calls for a better understanding of the processes at play. An analysis of the collective action among heterogeneous stakeholders involved in the ecological restoration of Grand-Lieu Lake, in the landscape management project in the Cévennes, and in the Vittel catchment management initiative, allows us to characterize complex situations of collective action mainly as design situations. Of the three case-studies, we analyse the Grand-Lieu situation in the greatest detail. The analysis reveals how stakeholders developed what we have identified as "intermediary concepts" and how these assisted them in successfully engaging in a collective design process. In this paper, we discuss the value of the notion of "intermediary concept" to stakeholders involved in a situation as well as to a researcher observing and analysing a situation.

I Heterogeneous collective action situations are design situations

1.1 Characterising heterogeneous collective action situations.

We focus on collective action situations between heterogeneous stakeholders (Teulier, Cerf 2000) for which we give the following definition: "These situations mix various actors belonging to different institutions which can assign different issues to the project, they mix designers and final users with various expertise which all are needed to carry out the design task". The main characteristics of the collective management of such complex situations are identified through the study of three case studies in France:

- A post-fire landscape management initiative in the Cévennes hills that involved foresters, farmers, hunters, Mayors, Members of Parliament, researchers, and firemen over a period of nearly 20 years after the great 1985 fire that destroyed more than 4,000 hectares (Couix and Hubert, 2000).
- Integrated catchment management around Vittel mineral water. Between 1991 and 1999, this management initiative allowed the maintenance of dairy farming over a 3,000 hectare area in the watershed while ensuring low nitrate levels compatible with the requirements of mineral water production.
- Ecological restoration efforts at Grand-Lieu Lake initiated in 1980 and continuing to this day. The initiative involves governmental agencies, farmers, fishermen and environmental non-profit organisations (Marion and al 1994).

The situations presented here are case studies particularly appropriate to the observation of these characteristics. Because they involve a heterogeneous set of stakeholders, the conflicts are expressed more openly and reveal processes that are often so interconnected as to make them invisible. The lessons we learn from these situations regarding the process of collective

development are applicable to a wide variety of situations, particularly those involving partnerships between large organisations or even within a single organisation.

These situations often generate conflicts because of stakeholders involvement in the management of increasingly scarce and sought-after resources. Stakeholders interact in a new context in an arena "owned" by a variety of participants who find meaning in the situation as well as giving it meaning. Within a rich historical context, complex group dynamics often bring stakeholders to a crisis stage prompting them to collectively design a brand new situation. The design process brings stakeholders closer to a resolution of the crisis and to a modification of activities around a negotiated collective interest that can satisfy individual interests and practices.

Heterogeneous situations between independent stakeholders can thus be characterised by the following:

- individual interests appear in conflict with collective interests until a worsened stage is reached where all individual interests are affected or threatened.
- The solution is obviously concurrent: all stakeholders are affected or threatened concurrently. A "sign" that is interpreted as an immediate or expected threat to all makes its appearance.
- Design processes are collective and spread-out over time; there is no ready-made solution.
- Stakeholders from various worlds of interest are very independent. Their links prior to the situation's initiation, when the problem had not yet clearly emerged, were nearly invisible because they share in their daily life a common territory, or use or interest.
- The independence between stakeholders means that they are free to exit the collective design process at any point in time.
- But they may be also very interdependent due to their local interactions around numerous other stakes.
- Their social positions are usually very unequal and may be associated with the knowledge they hold or apply. Very often, those holding institutional knowledge are not the ones most committed to the knowing process.

As mentioned earlier, these situations are representative of situations within organisations or inter-organisations, inter-projects, or network-like organisations (Teulier-Bourgine, 1996). Such is the case, for example, in economic crisis situations affecting a particular region or a sector, as in urban or peri-urban crises where various types of stakeholders attempt to rebuild a community or to enhance quality of life. These issues are presented here to emphasise to general nature of the design processes observed.

1.2 Design process is a major characteristic of collective action situations.

In these collective action situations among heterogeneous stakeholders, design processes are key. The goal is to emerge from a new situation where all are concerned for a variety of reasons and often according to differing interests, with on or more pre-set solutions apparent to no-one at the outset. The situation is brand new and no satisfying solution is at first glance obvious.

The ability to characterise these situations as "design situations" is important in two major respects. First, it makes us better equipped to analyse them, most notably by looking at the findings from several disciplines studying design to see how well and under what conditions

they apply to these situations. Second, it enables us to facilitate the processes at play by taking advantage of methodological tools or artefacts already developed.

In the situations that concern us, what then are the stakeholders designing? Not a product such as an engine part or a piece of machinery (Jeantet 1998, Boujut and Blanco 2003), but rather a collective solution involving a set of very different activities, of diverse professional behaviours that affect the parameters of a bio-physical or socio-physical situation in a manner that is not a one-to-one relation relative to the introduced changes in activities or behaviours. It is not the nature of the artefact or of the idea, focus of intellectual production, or of the reasoning that determines the nature of the design activity (Simon, 1973), but the processes involved in this activity itself.

It is our belief that the presence of a design process within this type of situation is key. That's because the new solution must be entirely thought up and even the problem needs to be set. What will subsequently turn out to be recognised as a "solution", its development, the negotiation that will lead to a form and definition agreed to by all, and lastly its implementation cannot be imagined with any accuracy by a participant in the initial stage of the collective situation. Clearly, the design of a new solution is involved. Here, 'solution' is understood in its broad meaning, such as that of the solution in problem resolution (Simon, 1972), i.e., including both the final state of the problem, but also all the operators used to arrive at this state. This is indeed a cognitive type of design activity matching the definition given by Simon: the problem is ill-structured, and it is not a matter of selecting a solution among a set of previously known solutions.

A comparison of the characteristics of ill-structured problems with those of well-structured problems generates interesting insights. We list here the main characteristics of well-structured problems given by Simon:

1. There is a definite criterion for testing any proposed solution.
2. There is at least one problem space.
3. Attainable state changes (legal moves) can be represented in a problem space.

Simon's first design characteristic listed above requires the presence of a pre-existing solution or at least of a criterion to evaluate the latter; a condition that is not met in our case studies. Indeed, in the various situations examined, be they the Grand-Lieu, Cévennes or the Vittel cases, no-one knows of a possible solution right at the outset. Nor are there pre-set global criteria to evaluate proposed solutions. In the Vittel situation, for example, while it is known that nitrates must remain below a particular threshold specific to mineral water fountain, the type of farming activity in the watershed that will satisfy this requirement is unknown but everyone agrees that current practices must change. The "solution" must be of a systemic nature since all involved stakeholders use the same space. Over-simplified statements generated by a stakeholder may even become a source of conflict and result in a stalemate, as noted by Raulet (1993). Additionally, a process adding complexity (Callon, 1986) and providing a framework are needed (Raulet-Crozet,1999).

Regarding Simon's second characteristic, we find that the problem space in the situations we examined is absent. There is frequently an assessment or a trigger that calls attention to a problem, e.g., nitrate levels rise, the lake is dying, the forest is destroyed. But defining a problem within a problem space at the outset is not possible. Rather, a series of interlinked and enmeshed problems seems to be set and problem spaces mutually affect one another.

And lastly concerning the third Simon's characteristic, in our case studies, attainable state changes cannot be represented in a single problem space. This appears clearly in the Grand-Lieu case where defining such a state from one point of view, e.g., the reduction of water lilies, is of no significance to the other points of view. In the Vittel case, current dairy production is based on the highly productive Holstein breed requiring high inputs which cause nitrate leaching. Improving water quality for the Vittel mineral water company calls for re-thinking the entire livestock system: changing the breed, shifting from silage maize to pasture grazing and hay mowing, diversifying other crops. In the Cévennes, restoration of the forest requires diversification of tree species, new reforestation techniques resulting in more complex forest structure, and creating a mosaic of grazed clearings attractive to neighbouring sheep and goat farmers to make the area less vulnerable to fire hazard. Reconciling foresters and goat farmers is challenging in the Mediterranean. This represents a key challenge and central node in these types of situations. Each actor has proposed solutions but none can satisfy the entire set of stakeholders. Thus at the beginning of the collective process, the attainable states can't be formulated as belonging to a single problem space and stakehloders have to manage an ill-structured problem.

This essential difference, i.e., between an initial simple and often "technical" criterion, occupying a central position in the initial problem definition, and a final "systemic and collective solution", means that the process of design and of collective action among heterogeneous stakeholders requires time to set itself in motion: from several months in the Cévennes case to several years in the Grand-Lieu Lake case. The several months required by stakeholders do not represent an excessive constraint to the qualification of these cognitive design activities. "Classical" design situations, such as those studied in an industrial context (Jeantet 1998, Eckert and Boujut 2003), also require long periods of time in which problems are re-defined, reasoning interrupted, and repeatedly reconsidered.

How are design situations defined? Simon, characterising them as ill-structured problems notes that "*the boundary between well-structured and ill-structured problem solving is indeed a vague and fluid boundary*". The various overlapping process phases proposed by Simon referring to "… complex designs are produced by organizations …" "An initial stage of lying down general (and tentative) specifications is followed by stages in which experts are called up ("evoked") to introduce new design criteria and component designs to satisfy them. At a later stage, there is attention to inconsistencies of the component design, and a search for modifications that will continue to meet most of the criteria, or decisions to sacrifice certain criteria in favour of others. Each small phase of the activity appears to be quite well structured, but the overall process meets none of the criteria we set down for the well-structured problems." Thus as Simon suggested it here, ill-structured problems may be partly composed of well-structured problems. Nevertheless we agree that among different processes of heterogeneous situations that can be characterised as ill structured problems lies also well-structured problems.

Design processes in collective action situations with heterogeneous stakeholders are nevertheless different from other design situations. In these particular design processes, the negotiation process differs from that of all other design situations due to the high degree of independence enjoyed by stakeholders who may choose at any point in time to leave the collective design process. Negotiations between individuals, and to a greater extent between professional groups are frequently challenging and regard stakes that can affect the very survival of the professional group. In addition, individual consultations and conversations take place in parallel to the main visible process involving plenary meetings or workgroups.

One significant and original aspect of these situations is that design is tightly meshed with its implementation. It is also associated with the high degree of independence of stakeholders, and even more so with the way the process takes place: it is a social process entirely interwoven with a wide variety of activities. Numerous meetings between heterogeneous stakeholders take place, and in between these meetings, participants return to the routine practice of their profession, each community of practice once again confronted to the physical world of its practice, and forced to act in the situation that is itself the focus of collective design. For example, in the Grand-Lieu Lake case from 1988 to 1992, fishermen continued to fish in between meetings and continued to note the disappearance of high-value fish species, farmers continued to put their livestock on increasingly dry and non-productive pastures. The design gradually "matures" as people practice their activities, go through various confrontations, and experience the intrusion into their individual universes of the situation whose collective process design they are involved in.

However, since individual activities are somewhat separate, neither the coordination problems (Malone and Crowston, 1990) nor the negotiation process taking place around the design of the new object appear so fundamental in this type of situation, even though they are naturally ubiquitous. That is why we consider design processes as key elements in this type of situation and why we wish to focus our attention on them here.

II In these situations, intermediary concepts support collective design.

Jeantet (1998) described classical industrial design situations. He had shawn that one of the main characteristics of design situations is to resort to using intermediary objects in communication and negotiation among co-designers. Jeantet's definition of Intermediary Objects for Design (IOD) is: "These include objects produced or used during the design process, evidence and design action aids in relation to tools, procedures and stakeholders" (Jeantet, 1998). Such a definition places these objects at the heart of the design process. These objects are abstract entities emerging from action and have no substantial status outside of, and prior to the action.

Certain concepts used by stakeholders play a significant role as intermediary objects in collective action situations among heterogeneous stakeholders. Using the notion of intermediary concepts for design (ICD), which play the same role as Jeantet's intermediary objects, can serve as a framework and as a guide for participant-observers taking part in collective actions. The transition that we are suggesting, i.e., from IOD to Intermediary **Concept** for Design (ICD), is analogous to Norman's artefact to cognitive artefact transition (Norman, 1993).

As OID do, ICD articulate collective design. Integration and collective design do not take place around a diagram but rather, around one or more key concepts allowing stakeholders to assess, relative to their own constraints, the node embodied by this concept making sense for the collective goal.

- It results from the set of different knowledge sources without however resulting from any one source in particular.
- Its use by a stakeholder does not require understanding the entire system.

Why speak of 'concept' rather than 'object'? Not to remove the object's materiality, but rather to acknowledge that it can be shaped, find "resonance", and appear relevant in the various

worlds of action. From this point of view, the ICD holds the same creation of meaning function as "sign" (Peirce, 1960), in the context of worlds when it is used in management situations. The sign is therefore a transition between several worlds, and is interpreted in different ways in each world according to who is doing the interpretation (Teulier, 2000).

ICD as well as OID result from negotiations between the various stakeholder points of view and carry with them these various points of view. These intermediary objects or concepts are ideal for focusing the points of view of various stakeholders. In the Grand-Lieu case, for example, water level is identified after a genuine effort of characterisation of the future situation (even though it is set at 40 cm and not 22 cm in the beginning) but within the scientific forecast discourse; a discourse that does not acknowledge numerous other stakeholder points of view, a condition required for successful process outcome (Jeantet, 1998). Intermediary concepts must be easy for stakeholders to identify and observe. They have meaning in each partner's world of action, without resulting from a direct operational translation from any one partner.

2. 1 What is required to support the emergence of an intermediary concept.

In the Grand-Lieu Lake case, the intermediary concept that provided support to the collective process design is the "spring water level". In the initial phase of the case (1980-1990), the concept competed with other ones such as silting or the time a sluice gate remains open. The concept emerged during a work phase in which four different scenarios were discussed (1990-1992). From 1995 to 2003, it becomes a reference for all stakeholders committed to the lake restoration collective action.

Various steps in the discussions preceded the appearance of spring water level as an intermediary concept. In 1980-1981, the group's attention is on silting rate, plant productivity and the re-establishment of currents. These are concepts dominated by an ecological point of view. In 1985-1986, the group focuses on the balance of fish and bird populations, and the key concepts of that period are abundance of white fish, high-value fish, surface area covered by water lilies and the time a sluice gate remains open.

In 1990-1992, with a worsening ecological situation, a rescue plan is developed. Through a collective design process, four scenarios corresponding to four different spring water levels are developed. Building scenario of prospective design is a very fruitful way to organize design situation (Carroll, 2001). Carroll emphasized "…*why scenarios have become a pervasive design representation.*" … " *1) Scenarios are concrete in the sense that they are experienced as low-fidelity simulacra of real activity, but 2) flexible in the sense that they are easily created, elaborated, and even, discarded. 3) Scenarios keep design discussion focused on the level of task organization that actors experience in their tasks ('basic' tasks in the sense of Rosch et al, 1976) 5) this makes it easier for all stakeholders in a design, including end-users, so participate fully, and 6) creates a focal, use-oriented design representation that can be reused throughout the system development process …*"

Once the discussion stakeholders group had begun to be structured around these four scenarios, the intermediary concept of spring time water level merge. The discussing around scenarios marks this first time the "spring time water level" concept is used, because then stakeholders project themselves in a prospective way both for collective and individual action. This concept was to become the key intermediary concept providing a foundation for collective design. Initially, it appears as a reference point common to all four scenarios, then it

appears progressively as a major articulating point. Thus, in the restoration Grand-Lieu lake group, ICD use is linked to scenario use. ICD appears and is needed to assess the concrete situation and scenario helps actors to project themselves in these situations. ICD is a particular node, an articulating point in the scenario but both have a similar function of re-organizing collective design. Scenarios are more global tools than ICD.

The requirements from each profession-specific point of view is fed into the development of the scenarios, and then shape the lens through which the scenarios are subsequently interpreted. From the point of view of ecologists, a variety of hydrobiological, plant biology and population dynamics models are used (Paillisson and al 2002). From a farmer point of view, the ability of local inhabitants to accept the conditions for grassland use are assessed and discussed, and technical guidelines are developed.

A discussion phase takes shape around these four scenarios. Only one of these four scenarios can satisfy all stakeholders, it contains the following specifications:

- A 40-cm rise in spring time water level.
- A ten-fold reduction in phosphorus and nitrogen inputs.
- Dredging.

In 1993-94, failure to obtain public funding puts an end to the rescue plan in which the four scenarios had been discussed and the work groups become idle.

In 1995, another potential funding source emerges, but, because it does not enable the implementation of the rescue plan earlier planned for, it must be overhauled. A new draft of the rescue plan satisfying more modest funding is reviewed. Its key concept is still spring time water level, with however a reduced target of 22 cm instead of 40 cm. Spring time water level becomes really a concept that unites stakeholders and structures their interactions and proposals.

Four years later, results are better than those expected by ecologists. The various groups structure their actions around the 22-cm goal and the scientific knowledge is revisited: it now appears that 22 cm makes it possible to obtain significant results toward a reversal of the lake's eutrophication (Marion and Paillisson, 2003).

Certain phases common to the various case studies can be described. Nevertheless, caution is required when conducting this relatively arbitrary breakdown of very diverse and context-specific situations. These four phases may help observers to have a lecture of design situation, but they are only indicating repairs. Some of them may be absent or very briefly expressed.

- 1st phase: differences are expressed in terms based on other concepts that end up not being useful ICDs. This is the phase corresponding to Raulet-Crozet's phase of framework-building notion (1999). As reported by Raulet (1993), an approach confined to simplified problem-setting involving the main participants is not conducive to finding solutions. On the contrary, it is by complexifying the problem and by including all stakeholders that solutions can be found.
- 2nd phase: appearance of the intermediary concept relevant to collective design, but in competition with other concepts. The competing concepts included siltation, phosphorus and nitrogen levels (Marion and Brient, 1998), and fish population dynamics. At other period some concepts as actual reduction in water lily productivity, decline of botulism or increase in agricultural productivity were also competing

concepts. But they all were too particular and "one-vision oriented". These were used temporarily and did not succeed in being used by the entire group.

- 3rd phase: stabilisation, this concept becomes the key concept.
- 4th phase: How groups restructure themselves and redefine the positions of their worlds. A diversity of knowledge and knowing is able to feed into the intermediary concept and contribute to a resolution of the problem taking shape around it.

Jeantet (1998), for his own, propose to distinguish three states from 1)expressed need toward 2) calculated solution, then 3) to product drawn. Jeantet proposes an analysis of the translation process through the transition of one state to another. We try here to express our observation on Grand-lieu Lake in the grid these three states. But our belief is that chronological phases that we propose are more useful in heterogeneous design situations lecture. Looking at these three states for the Grand-Lieu Lake case is but instructive.

Goals expressed	**Calculated Goals** (scientifically calculated)	**Negotiated Goals** (implementation constraints weigh heavier here)
Clear water	Water height	Water level
	Maximum siltation depth	Dredging
Available pastures	Duration of ungrazed period, grass grow-back	No. of grazing days Key periods of availability
	Grass productivity	
Phosphorus and nitrogen levels	Opening of gates	Reduction of nitrate spreading

2.2 Characteristic of objects / intermediary concepts for collective design

Apart from the requirements for the emergence of intermediary concepts for design, we look at some of the characteristics providing insights into their role in design. How do these "intermediary concepts" function in real life?

As noted above, intermediary concepts emerge after a common search for solution and a certain degree of confrontation of points of view. The partners build them in the initial phase of their interactions, but their construction requires time and is not explicit. It is only after going through a number of discussions and confrontations that the intermediary concept does stabilise itself and takes on a key position. To a greater extent than in mechanical design situations, stabilisation around the intermediary concept represents a phase in the negotiation and collective design process in heterogeneous situation.

Once the ICD is identified and stabilised, it allows an integration of the points of views. The intermediary concept is continuously reviewed and updated. It also enjoys a high level of stability and resilience since, once it is agreed upon among stakeholders, it remains a steady point through which their exchanges transit and serves as a building block for the various design proposals.

The intermediary concept must be in agreement with the other concepts that are key to the exchange and collective development of stakeholders. Rather than doing away with the other

prospective ICDs, it re-structures them. It must agree with the set of all other criteria within all worlds of action.

The ICD as much as the IOD plays a pivotal role in collective design. The intermediary concept constitutes a common proposal and solution-testing link, around which the constraints of farmers, fishermen and park managers are acknowledged and around which negotiations needed for the design of a collective solution are at play. The goals of design enable the development of a solution to take place within a permanent confrontation between those participating in its definition: they are in agreement with the idea of integration or cooperative design. ICDs are produced, circulate, guide, channel or are tested, criticised, corrected, completed. In other words, they provide support to the efforts of stakeholders.

When speaking of intermediary concepts, we are not referring to the concept in isolation, or as a static and simple indicator, but rather we are referring to the concept as a site around which various scenarios and coordinated action systems transit. They form the building block for common scenarios and serve as a basis for the various specific scenarios growing out of the common scenarios. The specific scenarios that stakeholders build themselves within their own worlds serve to test points of view.

Intermediary concepts for design play a role in situating stakeholders relative to the group. In collective process design, the idea or constraint escapes from its author, that is the price of its becoming an object. And other stakeholders are confronted to this sub-set of requirements. The stewardship of the Lake's watershed and flood plain requires livestock raising, and for livestock raising, days of availability and opening gates are needed. ICDs, just as IODs only convey the author's intention by transforming it (Jeantet 1998).

After establishing spring time water level as an intermediary concept and after participants have related it to their own systems of action, it shifts from being a goal to attain and an object of negotiation to that of an object of reference and of regulation. One challenge posed by the ICD for heterogeneous collective design relates the need of its being actionable (Argyris, 1993, 1996) : its ability to be concretely implemented within each of the action domains of the concerned stakeholders. Beyond simply enabling communication, it must also become an instrument in the meaning of Rabardel (1995), that it be associated with action patterns among stakeholders for whom it has taken on an instrumental function (Rabardel, 1995). Stakeholders must have "a grip" on the intermediary concept.

2.3 Confrontation to physical objects and activities occurs within each world of interest.

The spring time water level ICD relates to the know-how and action of a variety of stakeholders as well as to technical knowledge; for fishermen, water level has become an indicator they have linked to their observations of fish populations and their catches over periods of months: water clarity, re-population of particular sites according to currents, etc. Similarly, livestock farmers have linked spring time water level to grass growth and to the number of days of grazing obtained. To them, the water level concept is actually understood relative to grasslands: it is related to the surface area of floodable grassland not covered by water. This natural and intuitive transition makes the water level concept perfectly operational, even for stakeholders who, un-interested in water, are interested in its absence.

Because of this, ICDs enable interactions with the physical world and represent the concrete action context for each stakeholder. When used by participants, they represent action contexts,

physical objects to which stakeholders are confronted, with their own action rationale. This link between the intermediary concept and a bio-physical object is significant, it constitutes its anchoring point. Nevertheless, the concept cannot be reduced to a bio-physical object because actors can't communicate through it and because it is viewed in multiple ways according to each of the multiple visions of stakeholders. It is as if the intermediary concept "contained" several visions, several objectives around a single bio-physical object.

The relationship between individuals and the group is affected by the relationship between a intermediary concept and a physical object. We have emphasised that the physical object is "perceived" in a particular manner according to the world of action. For example, farmers all perceive water level in relation to the available grassland surface area, this constitutes a "professional" point of view that they agree on concerning the situation and the intermediary object. Relative to the entire group, the relationship to the physical object is more complex and relates to the heart of the justification of the use of the intermediary concept. Everyone must refer to the same physical object: water level, nitrogen level at the root, mountain ridges, Cévennes roads and valleys. Nevertheless, as already mentioned, this tangible and irrefutable materiality is not an "objective" existence; stakeholders perceive it from their own world of action. The ICD is therefore polysemic and that is what confers it power as a communication medium.

This constitutes a difference with the IOD, which is the site where the various points of view are expressed by requirements on properties or forms that can be expressed in a common world: 3-D diagrams. The challenge in the situations we observe, is that bio-physical space is more complex and even more "multiple" than the 3-D diagram of a mechanical part, even one that has several components.

Why argue that it is a concept and not an object, as in St Brieuc scallop case (Callon, 1986)? That's because their multiple uses in a variety of worlds is more important than their physical presence. Such multiplicity of uses means that it is at times more the consequences of this concept (for example water level) than its physical translation that is meaningful in each world. This multiple-use aspect is found in both IODs and ICDs. The ability to function as signs in a variety of worlds also constitutes a reference to the pragmatists' sign. These are concepts also used by pragmatists, most notably Pierce (1960): "the meaning of a concept is the set of actions that can be built using it". It's also because the ICD emerge as a tool, it is not the aim of the group and the main object as the scallop was. The scallop-like in the Grand-Lieu Lake situation for example would have be lake restoration.

The ICDs all refer to varying degrees to a tangible physical object, or at least perceivable by the senses and anchored in the subject's physical experience. Either it can be touched or it can be measured: water level or root-level nitrates can be experienced via the senses. They can also be sensed through less tangible means: a client's satisfaction, the friendliness of an environment, the "safety" of a neighbourhood. The 3-D diagram also refers to a mechanical part, but with nearly one-to-one correspondence, in contrast to the concept, which allows room for even more interpretation on the part of stakeholders.

To enable their use by stakeholders, during both collective exchange or individual practice, the must be easy to observe and also easy to "handle" or to be measured so that they can become markers for action. Nevertheless, ICDs are not equivalent to indicators since there is no reference table. It is not through the measurement that they indicate in any particular

situation (i.e., 22-cm spring water level, or nitrogen levels at 10 cm under the roots) that they are operational. It is through the concept itself, independent of a position on a graduated scale.

In the situations we refer to, the physical link takes on even greater significance in light of the overlap of implementation in design. The goal is not to design a prototype upon which to reflect. But rather, it is to modify activities and behaviours and to act from the outset on the bio-physical world to change it. Design is not, therefore, a separate step within the action, there is a continuous to-and-from movement between collective design and individual activity (itself undergoing re-design under new conditions), and between collective design and collective activity.

The concept corresponds to a general concrete object (water level) which corresponds to other concrete objects that are key within each world: duration of availability of grasslands for farmers, water clarity and reduced number of water lilies for recreation seekers, dredging and balance between white fish and high-value fish for fishermen. The significance of the object's materiality is also found in classical design situations. Thus Prudhomme and al (2004) notes that design is an artefact production activity, and that designers constantly refer to known physical configurations. In design action, the relationship to the object's materiality is constant and strong.

In the three cases reported here, an instrumentation took place to implement the ICD. This practical instrumentation concrete should not be confused with that fact that the ICD is itself an "instrument. Three concrete instrumentations: suction cup to measure nitrates at root level in a sample of fields, zoning map to formalise the mosaic of forest and grazing areas, and the measurement of lake water level all confirm the relevance of ICD in the action domains of the various heterogeneous group of stakeholders.

Case	Concept	Instrumentation
Grand-Lieu Lake	Spring time water level	A meter
Col de Portes	For 3 different risk zones, then 3 different uses.	Zoning map
Vittel	Nitrates at roots level	Suction cup

2.4 Intermediary concepts are boundary objects.

The notion of intermediary concept, just as that of intermediary object (Jeantet, 1998), possesses several features in common with that of boundary object (Star, 1989) and hybrid object (Latour, 1991). The move from IOD to ICD that we are proposing poses a theoretical challenge: it entails a shift from physical object to abstract concept. We argue here that a concept may play the role of a physical or virtual object (Eckert and Boujut 2003) in design activities, as long as this concept has the characteristics we listed above.

When referring to heterogeneous groups with very different "definitions of the situation", Star qualifies as 'heterogeneous problems' those that include multiples points of view. He considers the concept of boundary object as essential to solving these problems: "*I call these boundary objects and they are a major method of solving heterogeneous problems. Boundary objects are objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across*

sites. They are weakly structured in common use, and become strongly structured in individual-site use."

Among these boundary objects, Star distinguishes between repositories, ideal types or platonic objects, terrains with coincident boundaries, and forms and labels. For the heterogeneous situations we have studied here, we may assign the notion of "ideal type" to water level and nitrate concentration under the roots, and "terrain with coincident boundaries" for forest fires. But these aspects are not developed further here.

An interesting aspect of Star's usage is the flexibility and the permanence of the object's identity. Permanence of identity and resilience: it serves as a nodal point for sustained exchanges across a variety of worlds. Flexibility, because it has a dual nature that allows a type of distortion essential to a link between heterogeneous actors and activity domains. It is weakly structured in common use to allow reciprocal adjustments and strongly structured in individual site to favour productive developments.

Relative to Cook and Brown's diagram, classifying the four types of understanding of epistemology of possession as: concepts, stories, skills, and genres. The term 'concept' used here refers to the concept that these authors place within the realm of the explicit and that of the individual. What we are proposing here, however, is to also use it in the collective world allowing a link with what is implicit (knowing). Not only does the ICD allow placing the knowledge of each within a new collective context, but it also allows finding new knowledge (a point we will address later) and new objects that fuel the conversation. The stories and the genre in our situations were the main constituent of what was shared within professional groups or within the various points of view. But they may not be shared by all participants of the heterogeneous situation, since stories as well as genres require common experience and activities. Nevertheless, stories and genres can be shared between groups and cut across professional groups (thus, inhabitants, be they farmers or hunters, may oppose each other on several issues while having common genres not accessible to the Prefect).

Not only do ICDs provide each stakeholder an entry point to commit to a design process in their own world, but because it has meaning to others, it conveys new associations of concepts and knowledge creation: "*The conversation can evoke novel associations, connections, and hunches – it can generate new insight and new meaning."* (Cook and Brown 1999, p 393); This exchange between points of view and between genres is a form of collective knowing, as noted by Cook and Brown (1999): "*Knowing entails the use of knowledge as a tool in the interaction of the world*". The zoning map in the Cévennes was built by a working group composed of foresters, livestock extension agents, firemen, hunting experts, and researchers. Prior to designing a common map, participants attended a number of meetings and conducted several field visits organised by each of them and highlighting what each found most relevant from their own standpoint. This process took six months in 1986 and the group felt the need for follow-on interactions after five years of field implementation. They hoped to assess their results and the difficulties they had faced in order to develop common guidelines to improve the forest restoration procedure and to replicate similar efforts to prevent fires in other situations. Once again, the group invited researchers to participate in this reflexive phase.

The ICD renews the way problems are set within everyone's world. Everyone can engage in reflection and hypotheses to resolve within the world of their own action the problem faced by all. Everyone can re-engage in the crisis situation with both their knowledge and their knowing. Not only does the ICD provide a cognitive entry point for all to rebuild their

individual point of view. But the ICD also confers the legitimacy to re-design a new situation via a renewal of roles. This social aspect of the ICD offers an exit from the conflict: participants are no longer tied to a stereotyped position and are no longer set on a position they must "defend". They are thrown into a new collective "definition" of the situation in which they can re-think their point of view and in which they have the legitimacy to offer this new point of view to the group. The ICD therefore brings about a renewal of the situation in terms of social legitimacy as well as on the cognitive level. Thus, points of view and legitimacies are dynamic within the group.

III Intermediary concepts allow collective design action, bridge scientific and technical knowledge, and promote organizational knowing.

ICDs are appropriate means to recognise and support the generative dance (Cook and Brown, 1999). Appropriate for recognition because we believe that they can be seen in all situations, they are quasi-inescapable, function as attractors of exchange of points of view, and nodes. Appropriate for support because they are easy to detect for any experienced participant offering a "hold" on the group's functioning and more specifically on a mandatory transition point of group design activity.

3.1 These intermediary concepts link knowledge and knowing

They facilitate the connection around them of the generative dance (Cook and Brown, 1999) between knowledge of different types and the collective learning processes required by the "*dispositifs"* implemented (Lundlin and Midler, 1998). In the Grand-Lieu Lake case, the interactions between scientific knowledge, technical knowledge and know-how of participants, and how they learn collective action is of particular interest. These are interactions and exchanges reiterated among the various knowledge types such as researcher scientific knowledge, cattle farmer technical knowledge and the knowing of park managers and stakeholders, in addition to the collective development of the points of view of the various participants generating a new situation.

The spring time water level intermediary concept expresses a general goal and facilitates the construction of new scientific knowledge, e.g., shifting from the 40-cm goal initially targeted to 22 cm, or the knowledge on bird consumption of local molluscs (Marion and al, 2001). The scientific rationales and research questions are configured in a new way within a new general perspective (Röling, 1990, Hubert and Bonnemaire 2000). Thus, knowing generates new ways of building scientific knowledge. Everyone's knowledge is placed in a new collective context, but new knowledge linking knowledge in current use and collective action is needed for action. Spring time water level becomes a new object that facilitates dialogue both between individuals within the group and between the various understandings held by an individual, knowledge as well as knowing.

ICD enables links between knowledge and knowing at several levels:

- Between individual stakeholders and the group. At the collective level, knowing within a design situation, for example of saving the lake interacts with the individual level. For example, knowing of feeding the cows with spring time meadows, thus operate with scientific knowledge and technical knowledge within the collective learning by designing together a new situation. By placing the knowledge of one stakeholder within context of

another can generate new knowledge for one stakeholder (e.g., birds feeding on local molluscs for the ecological researcher) or for the whole group.

- At the individual level, between the various forms of knowledge of stakeholders. It makes it possible for technical and scientific knowledge of animal nutrition to encounter farmer knowing in situations in which there is a need to change animal feed in order to transition toward lower-input dairy systems. To-and-for movement between livestock farmer knowledge and knowing for example generates a change in behaviour: he/she projects examines consequences in depth prior to risking to speak of it or to make a commitment.

- Interactions between knowledge and knowing also generate new knowledge within the group. As Cook and Brown (1999) emphasise, it is the translation by software developer (Nonaka and Takeuchi, 1995) of the term "twisting stretch" used by engineers in terms of a "trial-and-error process continued for several months" that facilitates the process de generative dance. "*In addition to the use of the different forms of knowledge, there was also knowing – that is, epistemic work that was part of the team's interaction with machine parts, bread dough and each other*." In heterogeneous collective situations, knowledge in organisational action is equivalent to collective skills for action, it also entails collective being together between a diversity of groups and institutions. Each stakeholder in the group learns from the situation the various roles and organisational capacities of the organised groups and institutions involved. Thus, in the Cévennes case, the involvement of the Prefect and the Minister with the aim of obtaining consensus on reforestation among the various lobbying groups, places all non-profit organisations and professional groups with a "citizens conference" framework where they both represent their own point of view and carry a citizen's point de view on collective interest. Interaction, repeated exchanges between the various forms of knowledge, for example the scientific knowledge of the ecological researcher and the knowing of managers and stakeholders, in addition to collectives building of the points of view of the various stakeholders which generates a new situation and new knowledge. This interaction improves the group's collective know-how and knowing. In this way, the collective process to build an overall solution with consequences for each stakeholder, gradually becomes established.

The link between knowledge and knowing can be taken advantage of in the facilitation of collective design. Thus, in the Cévennes, only the plenary group enjoys a political legitimacy. The facilitator sets up two working groups: the technical unit and external experts. The technical unit, with a fixed membership, is composed of people in work situations, participants are present because of their concrete involvement in the activities affected by their reforestation efforts. The facilitator strives to emphasise knowing, using, among other techniques, the "deconstruction" of knowledge forms that can minimize the expressivness of knowing, or by limiting their expression. The facilitator managed to put those holding knowledge in a situation of knowing by encouraging their involvement within the technical unit. In the same way, in the Grand-Lieu Lake case, the ecological researcher, representing someone holding the knowledge of an ecologist, is placed in a knowing situation when he becomes facilitator of a group Director of the Grand-Lieu Lake Park.

3.2 Intermediary concepts, because of their integrative effect on collective action, are key to knowing and to collective action.

We believe that in all collective design situations, the emergence of intermediary concepts and the fact that collective action finds ICDs sufficiently consistent to build upon them is a

condition to move toward a new solution that is collectively satisfying for a given period of time. Crisis situations that are unresolved - or resolved around solutions in which some of the interested parties are excessively unsatisfied - are those where collective design did not take place, frequently because the intermediary concept did not appear. Naturally, for the intermediary concept to appear, the problem needs to be set by the participants with legitimacy to set the problem, but it should also be set as a collective problem involving multiple heterogeneous stakeholders.

Each profession is associated with a point of view (Martin and al, 2001) and each point of view is associated with particular constraints. That is not to say that these situations are idyllic and equalitarian. In Grand-Lieu Lake case, the ecological researcher holds the legal power of Park Director, his legitimacy as an ecologist is a different matter. Locally he doesn't enjoy legitimacy as an ecologist. In the Cévennes, the facilitator enjoys the legitimacy bestowed to him by the Minister. And in the Vittel case, INRA team enjoys legitimacy to address water and agriculture but INRA is challenged as a negotiating party by the Agricultural Chamber.

As a connecting process for collective action, ICDs are essential to knowing, as a part of action, as part of the processes taking place within action, because these include important aspects of collective design. They make sense in the various worlds present in collective action and are therefore tied to the tacit and explicit knowledge of each world of action (Ecology, livestock-raising, fishing, tourism).

It is through action that stakeholders produce concepts useful to collective action, ICDs in particular. These are not generated via the reasoning of an isolated individual referring to a single action domain, but rather, they are collectively generated through confrontation and interaction. Several action domains through their constraints and lenses act on the ICDs. They are produced during collective action, at the heart of confrontation and satisfy the major goal of belonging to several action domains.

The strength of ICDs therefore arises from their being put to the test through action. The concept, created for and within collective action, is put to the test immediately. It is used immediately by the various stakeholders both in their own cognitive world, in their professional activity, and for the expression of their point of view in the heterogeneous group. It must serve to highlight their point de view relative to stakeholders with a different point of view, otherwise it is foregone. As soon as a concept is used again by stakeholders other than those who have defined it, it is used in a situation in reality, it is already used in a situation of collective action. In summary, the ICD must appear to be actionable in Argyris' meaning (1993, 1996), for each point of view so that it can be adopted. It must allow the expression of each point of view with enough efficiency both in the re-structuring of each domain of activity and in the exchanges so that it can become established durably.

If it turns out that it is appropriate to only a fraction of the stakeholders, it is not adopted by others in the exchanges and, since it is not a good tool for making oneself understood, even those who initiated its use eventually let go of it. Indeed, in collective exchanges, stakeholders attempting a proposal seek to make their point of view understandable and liable to be adopted. Also, during exchanges, participants involved in dialogue make sure they have reached a common understanding of the "conversation's common ground" or a grounding (Clark and Brennan, 1993). So ICD, when he emerge and set in use of the group reorganize the grounding of the group. All the exchanges will be done looking at it as repair point.

It is clear that in these types of collective actions, what is a stake is not simply a reciprocal adjustment among stakeholders (Mintzberg, 1981), but what is significant is the unified nature of the content of the action emerging from the confrontation between different rationales. Rather than co-ordinating or planning, it is the bringing together of a diversity of skills associated with heterogeneous constraints into the definition of a common action framework that really matters. In the course of design action (Jeantet 1998), knowledge originating from scientific models, constraints from the various professions and technical constraints stemming from financial constraints constitute reference models toward which people converge while challenging them through numerous iterations.

3.3 Bridging epistemologies

The notion of ICDs sets us free from the notion of shared representation, which, in the situations we are referring to, is not satisfactory. That's because neither representation nor sharing are relevant here. Representation is not at issue here: we are dealing with a physical object associated with a concept and it is that very concrete foundation which strengthens the concept within each world. But since the concept is not meant to "represent" something, how well it matches what it represents or how well the various representations fit together, is not relevant. In particular, it need not be "shared" since each world has its own coherent rationale in which the ICD takes on a meaning and there are few common points between them.

In dynamic epistemology, ICDs therefore play the mediator role that shared representations play in epistemology of possession. ICDs are however less constraining than shared representations and bring together through action stakeholders from very different worlds of activities. They enable stakeholders build these shared representations with minimal investment. As a link between stakeholders it is "minimalist", like an empty shell that stakeholders fill with what they find in their own worlds.

Linking the epistemologies provides the means to use the evocative and modelizing power from the two approaches. What the two methods associated with the two epistemologies yield actually complement each other:

- Problem-solving methods yield representations and models of the problem as it is re-defined by the professional world of each stakeholder.
- The detailed understanding of diffuse exchange phenomena and of the convergence of stakeholders in collective processes of dynamic epistemology allow to take in account social and situated process.

It is not easy to link the two approaches while engaging in a detailed analysis of a situation. ICDs are efficient tools, even for an observer: it allows to genuinely link the epistemologies by linking them around a commonly observed fact: the emergence of an ICD from the interactions in the group and changes in the interactions and actions around it. ICDs thus allow the linking between two epistemologies:

- by releasing us from the concept of shared representations and by framing interaction within a dynamic epistemological perspective.

- but also by linking local solutions within each world by becoming a goal or a constraint for each within a problem space that can be resolved with a problem-solving method. In this perspective, it allows the re-organisation of the problem space around it.

- In a dynamic perspective, ICD, with its link to physical objects within their worlds allows the co-ordination of stakeholders tied to their concrete action worlds and allows them

to engage in the collective construction of a new situation that is clearly "situated" in the physical realm.

ICDs are therefore linkages between two epistemologies that allows a re-structuring around it, the generation of new knowledge, of problem-solving processes in the cognitive sciences sense (or in the sense of epistemology of possession), interactions between knowledge and knowing and the link with the physical realm in the dynamic epistemological sense.

IV Conclusion

We have shown that situations of collective action among heterogeneous stakeholders constitute design situations in which a group of stakeholders with a diversity of points of view and goals jointly design a new situation that re-defines their individual actions.

In these situations a concept becomes key to the collective design activity. We have named it intermediary concept in reference to Jeantet's intermediary object notion. This concept requires time for it to emerge and then stabilises itself. It then possesses great resilience in the face of subsequent collective action. It seems to always make an appearance in situations moving toward solutions acceptable to all stakeholders.

As Jeantet (1998) does, we emphasise the heuristic value of the inclusion of intermediary objects in the observation of design processes. It is useful to note the presence of ICDs as entry points for the observation of situations of collective action among heterogeneous stakeholders to better understand stakeholder negotiation and the building of joint action.

ICDs make useful criteria indicating linkages between knowledge and knowing. They show that different epistemologies can be bridged. They also constitute a good vantage point for the observation of the generative dance between organizational knowledge and organizational knowing that organizations need to establish. They allow the creation of new knowledge and the design of collective action.

- They provide a link between points of view
- They are easy to observe but must also be easy to perceive or to measure so that they can become markers for action.

This knowledge-knowing link that allows the generation of new knowledge cannot be conceived without action. The collective situations we observe are situations of design and collective action. Thus, organizations should establish a generative dance between organizational knowledge and organizational knowing, helping them with ICD emerging in design collective situation.

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