Interactive knowledge construction during the collaborative building of an agricultural Community Information System: the Hien Valley experiment

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Abstract

The design and building of Community Information Systems highlights new learning processes associated to the paradigm shift from knowledge transfer to interactive knowledge construction. In this paper we exhibit an innovative framework where arguments for the role of conversational processes in the building of consensual knowledge can be theoretically grounded, and examine the participative building approach adopted in the Hien Valley CIS under the light of this framework.
We first describe the key part of the "collective analysis" phase, consisting in the design of goal diagrams.
We then briefly browse through some theoretical background related to conversational learning.
We finally propose a framework where the collaborative CIS design activities and the direct confrontation of territorial practices both contribute to interactive knowledge construction.

Résumé

La construction d'observatoires du territoire met en lumière de nouveaux processus d'apprentissage associés au changement de paradigme entre transfert de connaissances et construction interactive de connaissances. Dans cet article, nous proposons un cadre innovant pour donner un fondement théorique au rôle des processus conversationnels dans cette construction interactive, et réexaminons l'expérience de construction participative de l'observatoire de la vallée de l'Hien à la lumière de ce cadre.
Dans un premier temps, nous décrivons l'étape clé de la phase « analyse collective » consistant à produire les diagrammes d'objectifs.
Nous explorons ensuite brièvement quelques références théoriques liées à l'apprentissage conversationnel.
Nous proposons finalement un cadre conceptuel dans lequel la construction collaborative de l'observatoire et la confrontation directe des pratiques territoriales concourent à la construction interactive de connaissances.

Introduction

Community Information Systems (CIS, *observatoires du territoire* in French) are multi partners information systems dedicated to the interactive construction of scientifically validated knowledge. The building of a CIS aims at supporting collective action in relation with a given locally-circumscribed challenge. Within a CIS, the global dataflow is not under the vertical authority of one single partner like in private companies, but the result of horizontal negotiations within the community. And because of the diversity of skills and viewpoints among partners, the initial phase of "collective analysis" plays a crucial role in the project.
During this initial phase, two questions must be addressed: i) how do the stakeholders perceive the challenge? ii) how do the stakeholders practices impact the challenge ? The emergence of a shared representation of the territorial practices and objectives is therefore required to bridge the gap between the various stakeholders' expectations and a set of shared goals for the CIS.
This paper relates this emergence of a set of shared goals during the building of a CIS in the Hien Valley, and then attempts to analyze it under the viewpoint of interactive knowledge construction.

We first describe the key part of the "collective analysis" phase, consisting in the design of goal diagrams.
We then browse through some theoretical background related to conversational learning.
We finally propose a framework where the collaborative CIS design activities and the direct confrontation of territorial practices both contribute to interactive knowledge construction.

Drawing the goal diagrams when building the Hien Valley CIS

The Hien Valley is a small region (96 km2, 8600 inhabitants, and 75 farms) in the French Alp foothills, mainly concerned by agriculture and livestock. A report from the local water commission drew up in 2002 a critical description of superficial and underground water quality, and a diagnosis was ordered by the French government in 2004. As the local actors (the mayors of the municipalities, the representatives of the farmers as well as the water suppliers Unions) argued that a single diagnostic was not sufficient for setting a collective action, it was decided to build a specific CIS dedicated to the "water quality" challenge.
The overall approach adopted for building the CIS has been described in (Barzman et al 2008). The idea was to bring together all the local actors concerned by the "water quality" challenge (agricultural production, State agriculture and environment services, non-profit environmental protection, local water management, fishing, etc.) in order to "collectively address the multiple perceptions and interests and to tackle the complexities and uncertainties inherent in the agriculture environment relationship".
This section describes the key step in the initial phase of "collective analysis": the emergence shared goals for the CIS. We first describe the settings, then explain the formalism used for representing the actors and goals and finally present the results of the experiment.

Settings

Building a CIS is a collective project requiring a contractor, a supervisor and an approach articulating together the "collective analysis", the "modeling" phase, the "implementation" phase and the "evaluation" phase. In the case of the Hien Valley CIS, a technical committee composed of people from agricultural/environmental administrations, regional planners, assisted by CIRAD researchers, played the role of supervisor.
During the initial step of "collective analysis", two kinds of settings alternated:

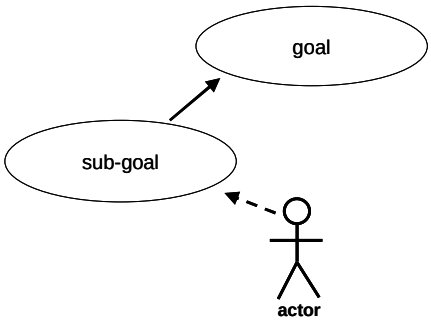
- Thematic **workshops** conducted by the members of the technical committee and grouping stakeholders having similar or interacting activities. Each stakeholder was asked to explain their activities and objectives in regards to the "water quality" strategic challenge. Progressively, they were asked to express their goals in a more concise way. During this simple exercise, through the trial-and-error process it appeared that many interesting concepts (agricultural, environmental, economical …) linked to the common territory emerged, as well as expectations about the information content of the CIS; they were carefully recorded.
- Collective **meetings** for drawing "actors and goals diagrams" with the help of the simple formalism presented below. During the meetings, the technical committee played the roles of "moderator" and "secretary" of the **collective debate**; they drew the diagrams under the guidance of the assembly. The diversity of individual goals were linked through a hierarchy going from most specific to most generic, forming the "stakeholders' goal diagram". The most generic goals that emerged from this exercise formed the basis of yet another diagram representing the "CIS goal diagram". Both diagrams were projected during the meetings and participants were prompted to react and modify them.

Formalism

UML (unified modeling language) is a widely spread "language" aimed at modeling information systems; one of the major benefits of UML lies in the graphical formalism and the readability of the models which are produced; it can be used both as an information management tool and as a

communication tool between actors. However, UML does not provide any specific formal representation for goal diagrams; we therefore had to imagine a simple formalism by derivation of the UML use cases, initially added to the UML toolbox by (Jacobson 1992) to illustrate system functions from the point of view of users. The four “graphical objects” of the formalism we adopted are illustrated in Fig. 1:

- actor, defined as a person or a group of people sharing an agricultural or territorial practice
- goal, defined as "something that a stakeholder hopes to be achieved in the future"
- link between actors and goals
- link between sub-goals and goals, either for indicating ‘generalization’, ‘inclusion’ or ‘extension’; for the sake of simplicity, we do not enter in these details within this paper



Fig; 1. The “actors and goals” diagram formalism

Results

The rich matter initially collected during the workshops is partly illustrated through the diagram in Fig. 2., which gives an idea of what was produced during the first meeting. The individual mental representations were translated into a unique diagram where redundant goals were eliminated. Main goals relate to agriculture, water quality and natural environment, needs for a communication tool. The “Water and environment” part (lower part of the illustration) is presented in Fig. 2 in a more detailed way: it presents the stakeholders’ goals in a schematic form, and shows that the restoration of water quality is a goal supported by most actors.

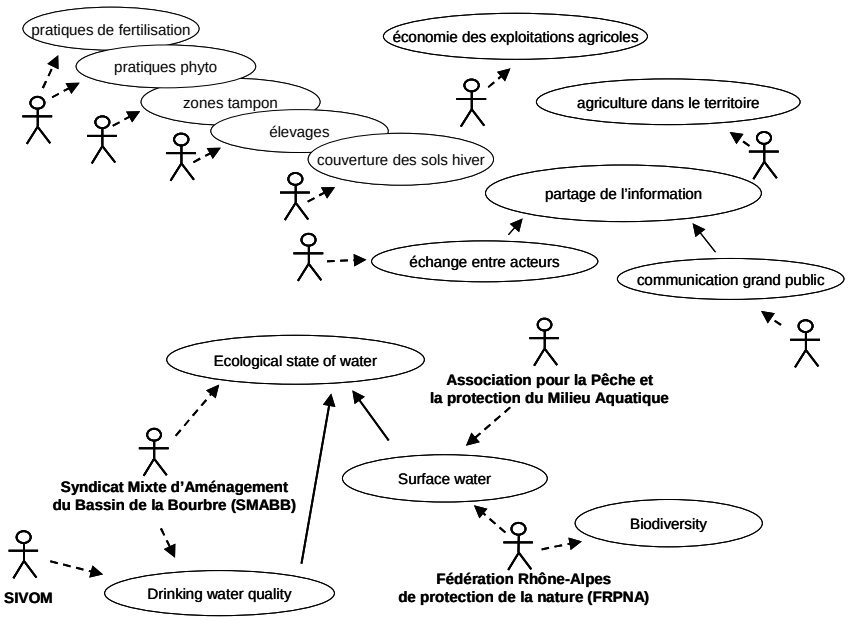
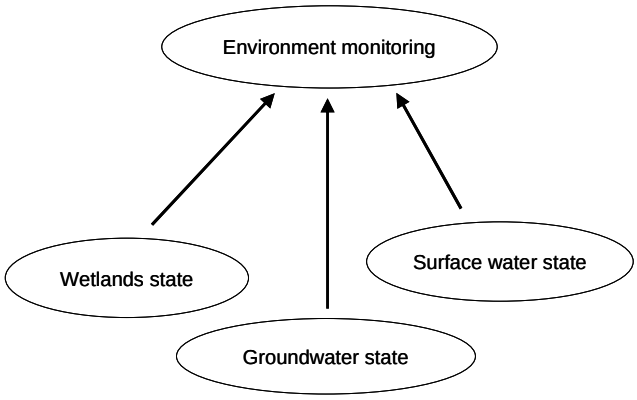


Fig. 2. Part of stakeholders’ goal diagram in Hien Valley – first meeting

After this first meeting, the workshops were oriented towards the expression of more generic goals, with the help of the formalism.
Then a second meeting was organized to produce a set of generic goals CIS goals validated by the group. Part of this set of concepts are illustrated in Fig. 3, which the focus on "Water and environment"; it reflects an emerging consensual vision of what has to be studied and communicated through the future CIS.



Fig; 3. Part of the CIS goal diagram in Hien Valley – second meeting

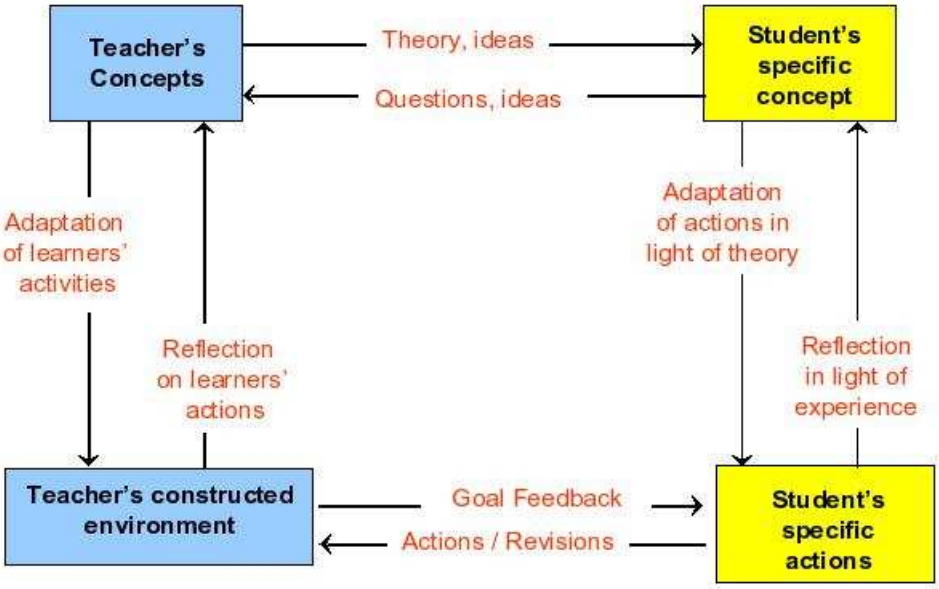
It is interesting to note that the final CIS goals were collectively discovered without the presence of any leader. The alternation of two kinds of settings (thematic workshops / collective meetings) resulted firstly in the integration of individual contributions around a shared skeleton, and secondly in the emergence of a shared representation on top of factual descriptions of activities and goals.
In this paper, we propose to interpret this "interactive knowledge construction" process as the reciprocal influence between the shared abstract representation produced by the group during the **meetings** and the factual descriptions of the activities of stakeholders given during the **workshops**. The global setting, where concrete interactions alternate with abstract discourse, seems indeed to share a number of features with a "conversational learning model" scenario, which we present in the next sub-section.

Theoretical explorations

In this sub-section, we refer to the Sciences of Education and exhibit a model in which conversational processes play an important role in knowledge acquisition; we then briefly analyze the psychological processes occurring in the learner's mind in order to connect the learning model to a modern theory of the brain. Our aim here is not to enter the details of sophisticated theories, but to set the basis for a coherent framework establishing convincing links between the stakeholders' mental processes and the conversational processes occurring during CIS building.

Laurillard's conversational model

The importance of conversational processes in learning is well-known since the conversational model of (Pask 1976), from which Diane Laurillard has taken inspiration. In (Laurillard 1999) she puts the focus on knowledge acquisition in a framework intended for higher education
Her conversational model is illustrated in the following diagram (Fig. 4.), borrowed as well as its comments from Daniel K. Schneider:
http://edutechwiki.unige.ch/en/Laurillard_conversational_framework



Fig; 4. Laurillard's conversational model

Four kinds of activities (communication forms) that happen in 8 kinds of "flows" in the model.
(1) Discussion between the teacher and the learner
- *Teacher's and learner's conception should be mutually accessible*
- *both should agree on learning objectives*

(2) Adaptation of the learner's actions and of the teacher's constructed environment.
- *Teacher must adapt objectives with regards to existing conceptions*
- *Learners must integrate feedback and link it to his own conceptions*

(3) Interaction between the learner and the environment defined by the teacher
- *Teacher must "adapt to world", i.e. create an environment adapted to the learning task given to the learner*
- *Teacher must focus on support for task and give appropriate feedback to the learner.*

(4) Reflection of the learner's performance by both teacher and learner
- *Teacher should support the learner to revise his conceptions and to adapt the task to learning needs*
- *Learners should reflect with all stages of the learning process (initial concepts, tasks, objectives, feedback, ...)*

Laurillard distinguishes two levels in the teaching/learning interaction:

- the lowest level is the level of concrete actions occurring in the context of the teacher's constructed learning environment;
- the higher level is the discursive level ; the conceptual representation of the student is the result of both his own reflection upon the concrete actions and of his conversation with the teacher.

In the diagram above, the horizontal arrows illustrate the interactions between participants occurring at the two levers.

The vertical arrows illustrate cognitive processes, which Laurillard labels 'adaptation' and 'reflection'; in order to deepen our understanding of these processes, we have looked for theoretical references both in psychology and in neurobiology.

Psychologists have long studied the subjective mirroring between mental activity and events of the outside; one of them, Piaget, describes it in terms of functional patterns embedded in the individual's *cognitive structure*:
"Cognitive structures change through the processes of adaptation: assimilation and accommodation. Assimilation involves the interpretation of events in terms of existing cognitive structure whereas

accommodation refers to changing the cognitive structure to make sense of the environment. http://tip.psychology.org/piaget.html".

This subjective mirroring has also long been a subject of inquiry for neurobiologists and neurophysiologists, who aim at grounding the functional patterns upon physiological features. According to the now commonly accepted "Theory of Neuronal Group Selection" in (Edelman et al, 2000), what Piaget calls our cognitive structure can be described as the result of three distinct evolutional processes:

- developmental selection yielding the primary repertoire (initial anatomy of the brain).
- experiential selection: overlapping this early period and extending throughout life, a process of synaptic selection occurs as a result of behavioral experience… this yields the secondary repertoire.
- reentry between the various maps of the brain. Let us imagine a string quartet in which the players would be linked by myriads of fine threads that coordinate their individual performances; in our brains, the "threads" are actually parallel, reciprocal fibers connecting separate maps.

These two references give a very accurate light on the ability to 'assimilate' and 'accommodate' through the dynamically adjustment of our re-entrant neural maps, therefore giving solid arguments explaining the cognitive processes which constitute the vertical arrows in Laurillard's model.
In Laurillard's framework, learning happens at the crossing of the "horizontal" conversational processes and the "vertical" cognitive processes. The last section of the paper is an attempt of adapting this framework in order to interpret the "collective analysis" in the Hien Valley CIS design as interactive knowledge construction.

The 3 worlds paradigm

Before settling a general framework, we have felt the need for some kind of "theory of reality", in the meaning of a philosophical starting point establishing that there is something to learn about. Looking for this starting point, we have found some convergence between Karl Popper's theory of reality, the "semantic triangle" of Odgen and Richards and the philosophical default position of (Searle 1969). In (Popper 1978), three sub-universes called the "three worlds" interact:

- W_1 is the world of physical objects and events, including biological entities;
- W_2 is the world of 'subjective' knowledge, the realm of individual memory where the binding of experiments takes place;
- W_3 is the world of the products of the human mind, including culture and language; it is the world where 'objective' knowledge can be expressed.

In (Odgen et al 1923): W_1 is the world of "referents", W_2 is considered as a process called "reference", W_3 is the world where "symbols" are assembled in linguistic expressions.

According to this paradigm, knowledge firstly consists in the mental objects of W_2 supported by individual cognitive structures. Those are definitely private and cannot directly interact or communicate from one human to another. However they can influence each other with the help of conversational processes associated to a shared context, i.e. with the help of "symbols" of W_3 unambiguously associated to "referents" of W_1. This mutual influence can be described as a "synchronization" of cognitive structures during scenarios obeying the following settings:

1. a first interaction at the level of "referents" ;
2. a second interaction at the discursive level, each actor associating his own chosen symbols to the shared "referents" ;
3. both interactions simultaneous, so that the experiential selection in the respective cognitive structures can be somewhat "synchronized" by linking the same symbols to the same referents.

A framework highlighting interactive knowledge construction in CIS building

Although both Laurillard's scenario and the Hien Valley scenario share the settings described above, we have to point out one important difference:

- there is no teacher in the Hien Valley settings, although the members of the technical committee "teach" the UML formalism to the stakeholders at the beginning of the experiment. The members of the technical committee are not in the position of teachers regarding the CIS goals ; there are no pre-existing "conceptions" or "theories" to be taught to the stakeholders. While Laurillard's scenario is clearly a pedagogical scenario; the Hien valley experiment is no more than a "collaborative scenario".

However, the settings described above allow the drawing of "horizontal" and "vertical" arrows, in a way very similar to Laurillard's framework.

Horizontal "flows" can be observed at two different levels. The lowest level of "concrete actions" is the confrontation of agricultural/environmental practices, and most conversational processes occurred at that level during the *workshops*. The higher "discursive" level consists in the conversational processes about abstract representations leading to CIS goals during the *meetings*.

Vertical "flows" in Laurillard's model can also be traced quite easily in the CIS scenario. By reflection in light of one's own experience/practice, each stakeholder produces concepts adapted to the formulation of his goals. Reciprocally, in light of the shared CIS goals, each stakeholder reconsiders his environmental/agricultural practice, and may even adapt it. We can refer to Piaget's description of the reciprocal influence between the two conceptual levels:

- the cognitive structures of the stakeholders *assimilate* their own activities and help the building of "actors and goals diagrams" as result of their own description of their individual practices provided during the *workshops***;**
- during the *meetings* these cognitive structures *accommodate* in order to make sense of the other's description of activities and events occurring on the same territory.

The emerging shared concepts are 'what is learnt' as a result of those horizontal and vertical flows. They are not the result of a pedagogical scenario, but a side-effect of collaboration between stakeholders having distinct territorial practices and accepting to build together a CIS.

Moreover, the use of a simple UML formalism for producing "intermediary" objects plays an important role in the learning process, as explained in (El-Kechai et al 2006) where we find: "We observed the pre-eminence of the representations and the objects created, manipulated, and finally we claim that they support knowledge creation and therefore allow the development of a common understanding of the design situation (i.e. the problem and the solution)". It is noticeable that in the case of the UML formalism, the "intermediary" objects including the "specialization/generalization" relation directly map the cognitive associations (environment monitoring involves the management of wetlands state, of groundwater state and of surface water state).

We summarize these arguments in Fig. 5. representing two stakeholders "i" and "j" co-producing some conceptual representation during the design of a CIS related to their practices.

- the collaborative design of the CIS, through conversational processes aimed at the emergence of a common conceptual representation, plays the role of discursive level where the objects of W_3 (actors and goal diagrams) are exchanged in relation with the sharing of the "referents" of W_1 consisting in individual practices related to a shared territory;
- the processes of "assimilation" and "accommodation" , internal to the respective cognitive structures W_2 (i) and W_2 (j) of the two different stakeholders, are synchronized during those simultaneous interactions, which hopefully will converge into a shared representation. If this

convergence occurs, the synchronization process may be called “interactive knowledge construction”.

The symmetry between the roles played by “i” and “j” is an important characteristic of this framework, which is applicable to any number of interacting stakeholders. The moderating role of the technical committee does not appear in this diagram; its role is however crucial for both horizontal flows.

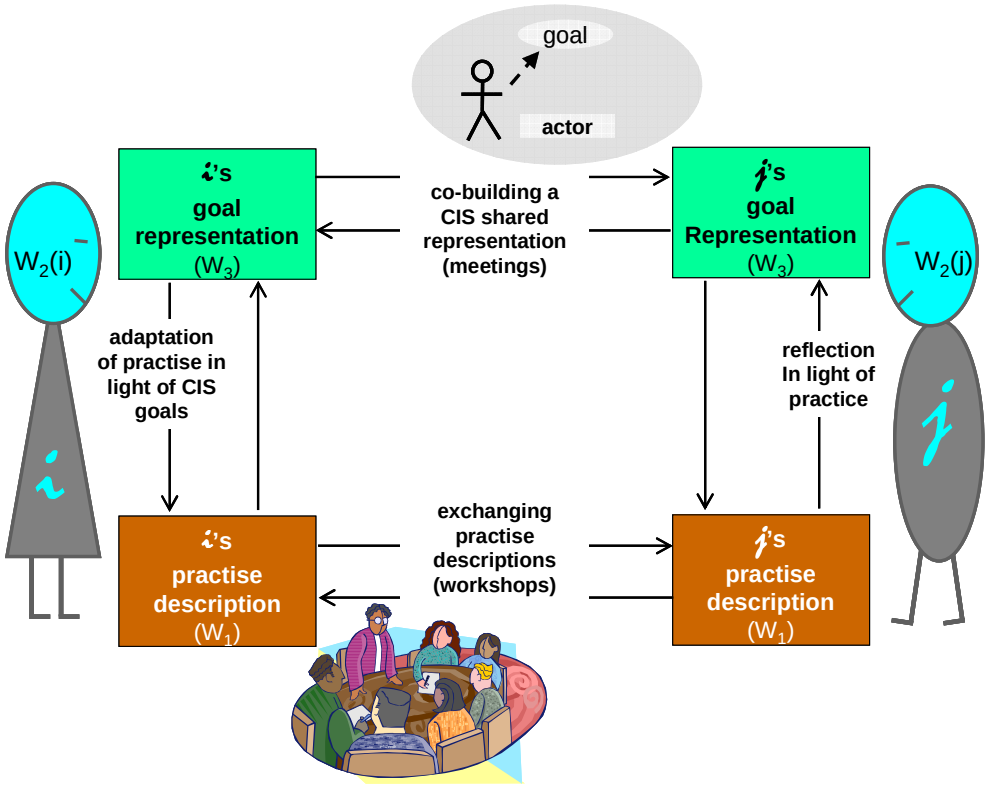


Fig. 5. Interactive knowledge construction during the collaborative building of a CIS

Discussion

In this paper, we have first described a “goal diagrams collaborative drawing” experiment, then looked for theoretical arguments allowing an interpretation in terms of learning, and finally presented a framework attempting to highlight interactive knowledge construction during the collaborative design of a CIS.

The “goal diagrams” construction process has been chosen as a prototypical illustration of the CIS design because of the simplicity of the formalism; however, such collective construction occurred during several other steps of the study, for instance when formalizing the CIS content through class diagrams.

A serious objection to this attempt could be the question of the assessment of learning with such settings: how can we evaluate learning in a context where no pedagogical goal has been initially expressed? This is a difficult question, for which we hope to find elements of answer in a near future. Taking inspiration from (Coudel 2009), and the notions of “human capital” and “social capital”, we intend to evaluate knowledge acquisition (seen as an evolution of human capital) indirectly, though the transformation of territorial practice (considered as an evolution of social capital).

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