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Michel Lample
Université de Brest, lample@univ-brest.fr

Denis Bailly
Université de Brest

Johanna Ballé-Béganton
Université de Brest

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A Social Metamodel to control the participatory process in complex system modelling

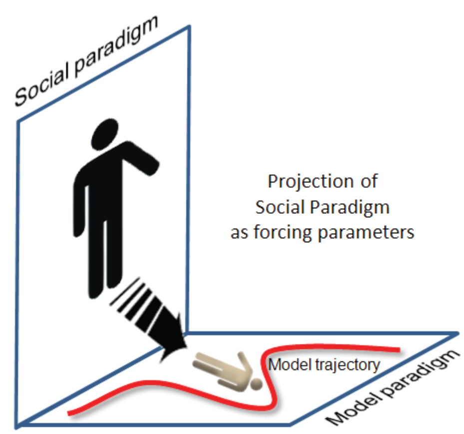
Michel Lample[a] **Denis Bailly**[a] **Johanna Ballé-Béganton**[a]
[a] *Université de Brest, UMR M101, AMURE, OSU-IUEM, 12 rue du Kergoat CS 93837, F-29238 Brest Cedex 3, France.lample@univ-brest.fr*

Abstract: The metamodel framework is a new tool for co-construction of models involving societal or political participation. Rather than an attempt to model the social factor by numerical techniques which amounts to project the social paradigm in the model paradigm, the metamodel framework provides a way to overcome the difficulties of social behaviour by an inverse projection of the model paradigm into the social one. The framework asks for a strict methodology based on a suitable agenda, a quality process and the management by an Architect team. Furthermore, this framework accommodates lean modelling techniques that system platforms are able to provide.

Keywords: *Metamodelling, participatory modelling, social modelling, co-construction, system modelling, lean modelling, Architecture, quality process*.

1. Introduction

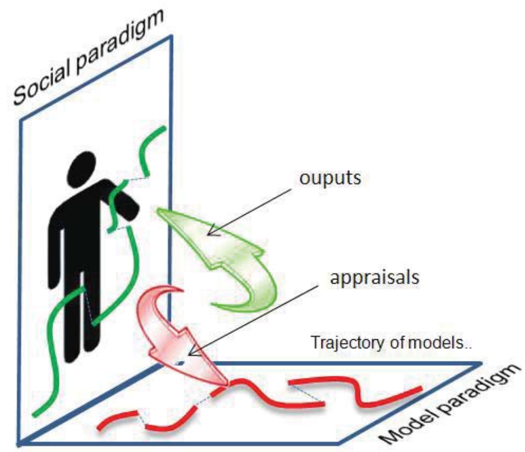
Problems that focus on Environment, Society and Economy (ESE) are the subject of increasing demand. Unfortunately, there are still many barriers to an efficient cooperation between science and society to address these problems and despite many apparent efforts the gap remains wide. On a smaller scale participatory methods are used increasingly as the most effective approaches to achieve sustainable resource management involving cooperation of scientists and stakeholders. But models that result from participatory modelling do not seem to meet the expectations (Cleaver 2001). It is likely that the causes are multiple and we argue that they are globally related to the "addition" of a kind of "social factor" to our classical environmental models. Mathematically, this "addition" can be viewed as the projection of a paradigm (the social paradigm) to the model paradigm. Traditionally, social issues are "translated" as forcing parameters or new functionalities in our programs, but doing this we miss the vast problem of the complexity of the social paradigm. Even the attempts to model the social with game theory remains criticized (Kay 2005, John Quiggin 2005). Sociologists recall us that: "*the social field is a game which rules are themselves played*" (Bourdieu 1997). These are key words to explains why we are only able to translate the social issues into the shadow of their real complexity.



In this article, we propose a new framework to improve the process of co-constructing models with stakeholders. Rather than looking for the best "projection" of social issues into the models, this framework promotes the inverse operation of projecting the "model paradigm" into the social field. It is in the social field that a conceptual trajectory will emerge, this trajectory giving rise to a growing family of models. This metamodeling process focuses primarily on the interactions between stakeholders and other actors rather than on the modelling process by itself. The metamodel promotes the most relevant trajectory of models.

2. The social metamodel framework

Our framework will promote the sequential building of a trajectory of models that emerge from repeated projections of the models into the social paradigm. This is a metamodel operation. Of course, the items we only can project into the social space of stakeholders are the various model outputs (conceptual models, systemic representations and numerical results). This "projection" has to be adapted to the different stakeholders' groups in order to manage their own "*refraction*" (acceptance of the outputs we describe hereafter). In return, it is essential to translate all "appraisal" of the stakeholders groups into suitable "design" for the modellers' team. Thus an oscillating process appears between modellers and stakeholders which results in a trajectory of models without mathematical continuity between them. Each emerges from the appraisal operated in the social paradigm.



This framework seems to be one of the best suited for taking the social paradigm into account in co-constructing models. But it does not escape the main difficulties encountered in modelling with stakeholders. These difficulties the metamodel framework has to face can't be viewed as simple technical difficulties but as "social attractors" responsible of the drift of co-constructing process.

2.1 Social attractors

The co-construction, such as marriage, leads modellers and stakeholders to face new problems they would not have met alone. The social issues who invite themselves into the modelling process lead to many difficulties we summarise in Table 1. They are all the more important that they act as an attractor affecting all co-construction process.

with social issues influence:	Modellers and models	Stakeholders
Modellers and models	Hyper stability / Integronsters Galápagos Syndrome	Refraction
Stakeholders	Problem stage False problems Actors driven approaches Solution sellers	Symbolic Capital Chimerical consensus

Table 1: symptoms and difficulties of co-constructing with modellers and stakeholders. These terms are described below.

Hyper Stability/Integronsters: Social demand leads our modellers to perform complex couplings and to add a significant number of parameters in their models. As a consequence, they can be faced with problems of numerical stability of the models (do we get a result?) more than problems of mathematical consistency (what result do we get?). We can observe that the problem of consistency merges with the stability one: modellers consider in many cases that as long as their models produce coherent and stable results, they are good. In other words we do not know really what our models produce and can unknowingly drift into "**integronsters**" (Voinov *et al.* 2013). On the other hand stabilizing such complex models produces a new generation of "structurally stable" models designed in an equilibrium perspective (Érdi 2010) and far from instabilities, bifurcations and non linearity expected from complex models.

Galápagos syndrome: we can observe how co-constructing with stakeholders may turn out to be hard to bear for modellers anxious to remain committed to a high level of production. Observable reactions can be self-appraisal and reclusive behaviour in what we call "*Galápagos syndrome*" because their production no longer remains consistent with the expectations of the group.

Problem stage: stakeholders are often in what we call "*problem stage*" and sometimes far away from the identification of the needs. Stakeholders can express a "*problem*" but not yet a "*need*". Bosworth (1993) explains that there may be a long intellectual process from the problem to a "need stage" and during this process, the objective of the co-construction (the target) remains "*fuzzy*". This is a challenge for modellers since it is difficult to design a model that may not correspond to a well defined need.

The **false problems** can block the co-construction process (Durance *et al.* 2010). They are the more frequent when they are generated by common wisdom (Godet 1990) or even by media: "*The first truths are the first error and the real problems of editorialists and political commentators are often false problems that scientific analysis must destroy to build its object" (*Bourdieu 1997).

We have observed how stakeholders may influence the process in what we call "**actors driven approaches**" (Lample *et al.* 2011 and an example in Lample *et al.* 2012). The stakeholders are able to foster the building of the model according to their own rationale. Of course, the researchers and modellers are not free from such social behaviour. They belong completely to the social game even if they pretend be "*objective and value neutral*" (Voinov and Gaddis 2008, Voinov *et al.* 2014). This is "[the] *conflict between the goals of science and the goals of the scientist"* (Reif 1961). As a consequence, it is common to see that stakeholders, modellers and even researchers may act as **solution sellers**.

Refraction is the term we propose to describe the stakeholders' variability in perceiving the model (conceptual model or its outputs). According to Jones (2001): "*humans are disproportionate information processor,* the output produced by the modeling process will be differently "refracted" on each stakeholder and may produce very different appraisal more determined by "*field effect*" (*i.e. the social field they belong)* than rationality of judgment. The social field defined by sociologists (see Bourdieu 1997), is a social arena of actors and of social positions giving identity to the group in its way of acting.

The **symbolic capital** is the most important belief that the actors are not about to forfeit. Even if they participate in the same project, the differences between stakeholders can remain important in what is called the "*symbolic capital*" (Bourdieu 1984). This is responsible of the most important tensions within the stakeholder group. An example of symbolic capital is the *yield of the land* for the farmers opposite to its *natural heritage* for the environmental associations.

The **Chimerical consensus** is another attractor the stakeholders are ready to follow. When they construct the most desirable conceptual model, "*there is no guarantee that it will correspond to anything that actually can exist"* (Gregory 1993). This is for Gregory one major weakness of the Soft System Modelling (Checkland 1981). We argue that the social rationale is what drives the co-construction process towards a chimerical consensus that preserves the stakeholders inside their own social field, even denying the truth.

2.2 Social organization around the metamodel framework

In order to implement the metamodel framework, we describe the essential working tools for its management and to avoid the drifts outlined before. The first tool is to clearly make a distinction between the actors involved in the process. We distinguish (Figure 3):

The <u>Resources</u> of the co-construction process are the modeller team involved in the model building. Among them are the scientists providing knowledge and scientific relevant expertise.

The Users are those who will use the results of the co-construction (the model) or will be impacted by its application. The Users may have their own knowledge that they express through model appraisals they can submit.

The Architect team has to carefully manage and document the exchanges between the Resources and Users. Considering that the scientists involved in the co-construction (as Resources team) are not really neutral because of the social game in which they are caught, they may act as "solution sellers". We define the role of the architect team of the co-construction independently from the modelling and stakeholder group. One of the essential role or this team is to adapt the various outputs of the models to the variety of the different stakeholders' fields (refraction problem) and to translate the social appraisals into scientific formulated return for modellers (to undo the "false problems" and avoid "chimerical consensus"). It is clearly an intermediate node that should not be bypassed. Of course, the Architect team must be scientifically qualified to be aware of all the science needed by the issue. If needed, this team can include facilitators and other experts of social consultation.

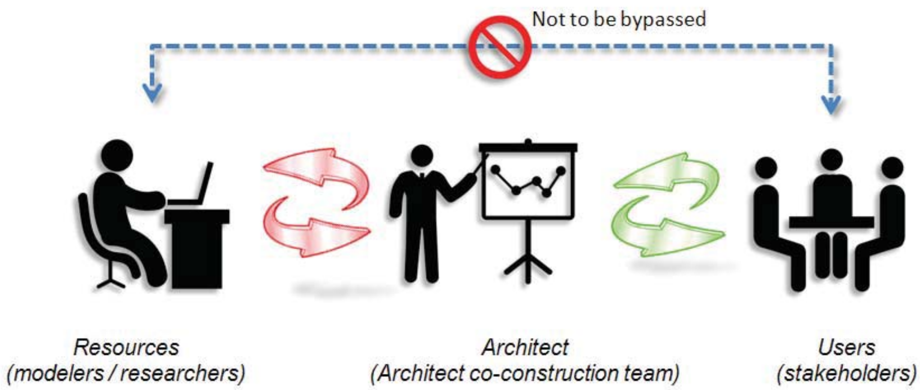


Figure 3: The actors of the metamodel framework. Between the Users and the Resources, the architect team manages the exchanges (appraisals, outputs...) and can't be bypassed to the risk of the drift of the process caused by actors' pressures following their social rationales

2.3 ECOF agenda

Classic model development descends from a long story of model building approaches and methods that engineers in computer sciences are trained in (Waterfall method, "V" methods, Spiral and so on). They are all based on a "*strong design"* which translates into the feeding of the model with the maximum of knowledge at its beginning (figure 4a). This stage corresponds to the maximum effort but it is done at the very beginning of the process which needs for a well defined target. This is not the case in socio-environmental issues. The sharing of the knowledge in the social group (the "deployment") corresponds to the end of the project after a "*rapid appraisal*". This makes this heritage not suitable for "*problem stage*" and "*fuzzy target*" issues.

The metamodel framework suggests a different way by first sharing knowledge in the social group (figure 4b). To counter the attractiveness of the ballistic way, we need an agenda that reflects these emerging steps and manages them. The ECOF agenda distinguishes four steps that reflect qualitative levels of the models and that are inspired by the classification of Brugnach *et al.* (2008) (Figure 4b):

- **E**xploratory: the problem is explored; false problems are ruled out and the first conceptual models are build
- **C**ommunication: we enter in this stage as soon as the models are able to produce the first numerical results thereby providing a new communication medium
- **O**perational: we enter in this stage when the results correspond to a measurable reality
- **F**orecast: this is a level of quality which ensures scenario modelling

A key point of ECOF agenda compared to other approaches lies in that the first rendezvous is not a "*design step*" anymore, which meant that the "needs" are clearly identified and that we are not in "problem stage" but in the build of the problem's solution. We see that this more sustainable approach we previously exposed (Lample *et al.* 2011) is particularly suitable for "*problem stage*" and "*fuzzy target*". Indeed, as the knowledge is shared by the group, the target becomes sharper. .

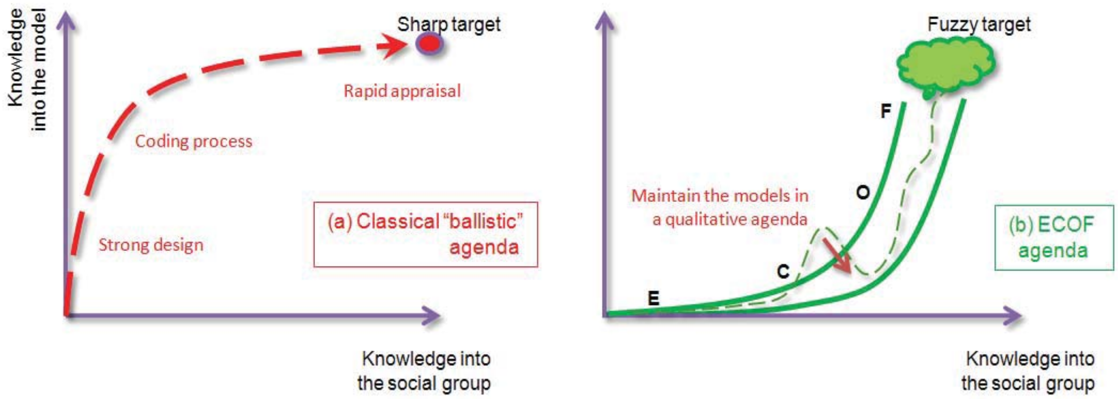


Figure 4. Classical and ECOF agendas for model building process, viewed in the dimensions of knowledge shared by the co-constructors group of and the dimension of knowledge feed up into the "model"

2.4 Lean modelling and system modelling

Of course, such an agenda requires that our models are kept as lean as possible. Thanks to system modelling that allows light models very suitable for stakeholder communication from conceptual representations to heavier numerical models (Ballé-Beganton *et al.* 2010), Figure 5).

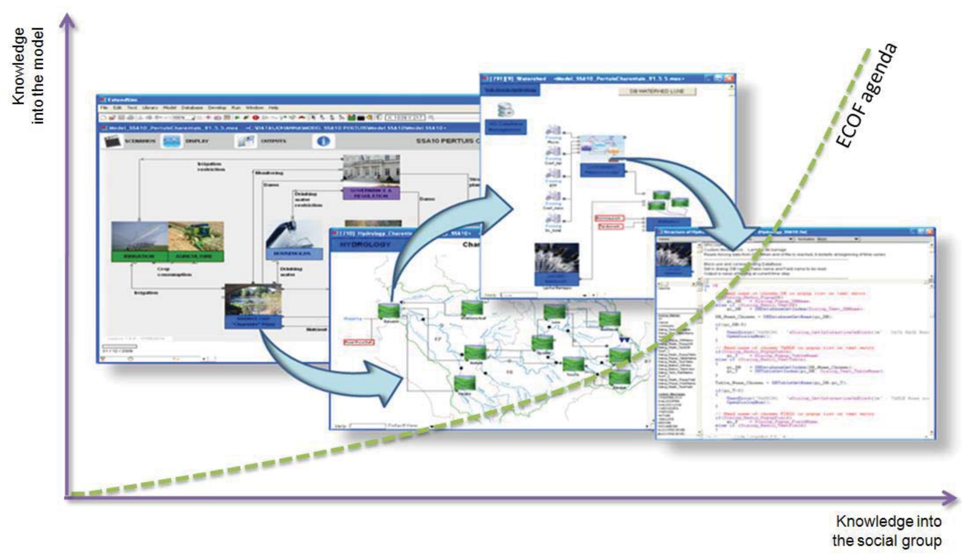


Figure 5. Example of iterative construction of a system model following ECOF agenda. The model begins with "empty boxes" which are the most fundamental systems composing the problem and their relations. As the knowledge of the study-site and its issues is accepted by relevant actors' appraisal, the adding of more science into the systems and sub-systems is done iteratively.

2.5 Quality process

All iterative processes can be drawn in terms of an oscillating part and a continuous one. In our case, the "*continuous component*" corresponds to the "*story*" of the participatory process, namely its ECOF agenda. There remains the oscillating part which basically corresponds to the exchanges between actors. These exchanges operate perpetually along the agenda and must be constrained to avoid the drift of the process (Galápagos syndrome, chimerical consensus) or stakeholders' fatigue. In that sense, this process corresponds exactly to a "quality process". Our inspiration for this process is the quality control norm ISO 9001 for industrial processes (the "Deming wheel" described by Deeming 1950). We adapted this quality process to the co-construction with stakeholders in the DFOA protocol (Moen *et al.* 2006) (figure 5). A Modellers' Design (at concept level) will be followed by a Formulation step corresponding to the realization of the design. Then this reality is presented to stakeholders (as the Output step) The outputs are to be translated by the Architect taking care to each stakeholder. Finally, the stakeholder feedback is expressed by an Appraisal step (a realization of what the stakeholders have conceptualized). This gives a new design etc.

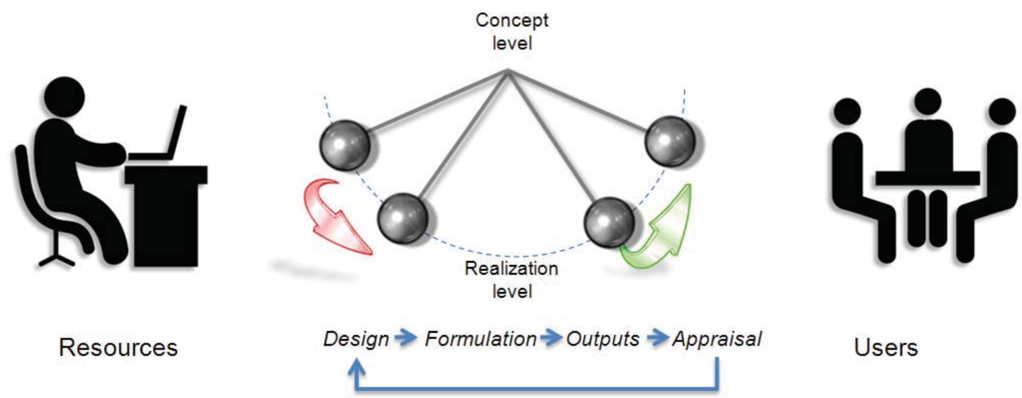


Figure 5. DFOA oscillating process that the Architect has to maintain between Users and Resources groups..

3. Conclusions

Numerical algorithms are not able to generate emergence, only a sequence of transitions within a given state space. This is what is done at different levels when trying to implement social issues into environmental models. These models are unable to draw the trajectories of new futures. Inventing new solutions, emergence of new techniques remain human prerogatives. As a consequence, too many models remain without practical application So we have to open our models' construction process to our stakeholders but not for a kind of rapid appraisal followed a scientific publication, but for all non academic, traditional and lay knowledge. The sharing of all sort of knowledge managed by a suitable framework such as the one we expose here is a key tool to obtain a model of emergence, that is to say a metamodel: "*a model whose states are models*" (Heylighen 1991).

The rationale of Metamodelling is to create a series of models by projecting model outputs to the social paradigm. Nothing is imposed regarding the debate process neither on modelling techniques even if system modelling seems to be highly suitable tool. With the metamodel framework, the two trajectories of the models and of their perception by stakeholders are evolving and mutually reinforcing like a constrained pursuit problem.

The backbone of the Social Metamodel is: The Architect core assuming the management of the project, facilitating debates and documenting exchanges; an agenda (ECOF) which marks out the process and prevents the attractiveness of ballistic drift and a quality process (DFOA) that maintains the exchanges in a productive framework avoiding the attractiveness of drift trajectories.

Finally, the metamodel seems to be an interesting framework to reconcile the Action Science (Argyris *et al.* 1985) and Analytical Science: indeed, in this framework Action Science is devoted to the Architect team while researchers remain protected in their role of providing the best science.

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