ICTs and Modeling: Current Challenges From a Constructivist Approach

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Abstract

This paper explores the relationship between the process of building models for organizational decision-making and the use of ICTs in the development of these models. In particular, the following hypothesis is taken as the focal point for this exploration: ICT may enrich the modeling process by expanding the boundaries of agreement. This hypothesis was set as part of a group discussion of the Systems and Information Society Network organized by the University of Lincoln[1]. The hypothesis is examined by considering two interpretations of the process of modeling. It is argued that only one of these provides sufficient ground to support the hypothesis. Some challenges facing the design of ICTs are put forward in this case. The paper uses as a grounding reference the use of ICTs in the planning process of Local Energy Systems – LES – in Göteborg (Sweden).

Keywords: Modeling processes, ICTs, transduction.

1. Introduction

In January 2001 a small group of people, with different backgrounds but a common interest in reflecting upon the role of ICTs in social processes, gathered together in the Athenaeum Club in London. During that meeting, the Systems and Information Society Network (SISN) was formally born.

After some initial discussions, this group finally agreed on a statement that was used to guide the work of the network. The opening question for the SISN was stated in the following general statement: "We want to explore the forms, which emerge from the co-evolution of information and communication technologies (ICTs) and social processes in order to clarify the resources and values that people can use to affect/effect changes of a desirable nature."

[1] The Systems and Information Society Network (SISN) was set as part of a project funded by the EPSRC (UK) under the direction of Professor Raul Espejo from the Lincoln School of Management. Further information of this project can be obtained at http://itsy.co.uk/sisn/

Around this opening question, the network soon grew up until it reached a size of about 30 members. During the following year and a half, the members of the network interacted regularly by using different ICTs and holding some face-to-face meetings. Twelve topics for discussion were agreed upon and explored with some detail during this time. These topics embraced a variety of themes that went from ethical considerations regarding the design and use of ICTs, until epistemological concerns regarding the role of ICTs in the (re)construction of the natural world.

One of such topics was put forward by a subset of the members of the network concerning the relationship between ICTs and the modelling process, usually carried out in policy making. This is the topic that is approached in this paper.

2. The hypothesis

Each topic was addressed by a group of around ten people; five assumed the role of participants and five the role of critics (i.e., acting as 'devil advocates'). Each topic (group) was identified by a particular colour. The purple group, for instance, gathered around the following initial statement: "Modelling is the effort by the 'here and now' to understand itself; Information and Communication Technologies (ICT) immensely increase the scope and detail of formal modelling and provide the tools to widen the here and now".

The expression 'here and now' refers to the resources and their relations that an organization deploys in its day-to-day production of whatever outcomes the organization is intended to produce. The statement proposes that the aim of modeling in an organizational context is to develop an understanding of these (inward and actual) relations. This process is, in itself, done using part of the same resources of the 'here and now'.

During the meetings, it became clear that the main concern of the group was not with "modeling the here and now" but with "widening the here and now" and, in particular, to explore how ICTs may contribute to this. At some point, it became apparent that under certain circumstances the modeling function might add a "spatial dimension" to decision-making and consensus; this is the dimension of interactions as distinct from the dimension of historical narratives (i.e., the narratives of the experts).

Following this, the group agreed to change the name of the topic for the following: "ICT may enrich the modeling process by expanding the boundaries of agreement". This paper, in turn, takes this statement as a hypothesis for exploration and offers a way to address its meaning and validity.

In methodological terms, this exploration is guided by a personal interpretation, made by the author, of successive attempts to design a Local Energy System (LES) in Göteborg (Sweden). The understanding of these experiences triggered a set of insights along which the exploration of the hypothesis is carried out. But before going into this exploration, let us review briefly what we are taking as a typical LES.

3. What is a LES

We have chosen a Local Energy System as a background for the present exploration for two main reasons. Firstly, because it is a sufficiently complex system (in terms of the characteristics that we will mention below) and, secondly, because its operation and the role of its main stakeholders are easy to grasp.

Figure 1 illustrates a general schema of a LES. This is a typical production system where a process is set to transform certain raw materials (e.g., coal) by means of some technological activities (e.g., large scale conversion technologies) into a particular product/service (e.g., heat, electricity) that goes through a distribution mechanism (e.g., District Heat Network, Electricity Grid) to the final users.

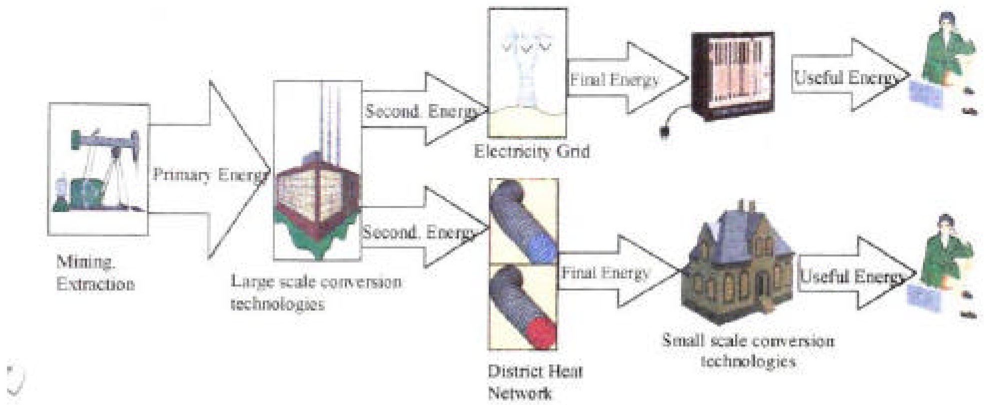

Figure 1. A general scheme of a LES (Jank 2000, p. 44)

The particular structure of these systems (i.e., the resources used, the roles engaged in pursuing the activities and their relations) may vary from one instance to another. However, there are some characteristics that remain invariant to all of them and which, in fact, allow us to distinguish them as valid instances of a LES. Here there are some of these [Jank 2000, p. 15-16]:

- They consist of highly interconnected subsystems such as District Heating, electricity generation, Co-generation plants, utilities, conservation in municipal buildings, incineration of municipal waste, etc. These subsystems are highly inter-dependent (i.e., changes in one subsystem may have effects in other sub-systems).

- Energy system planning interacts with strategic planning in other fields (e.g., urban planning or transport system planning may affect the energy system).
- Changes in the energy system may affect residents, local industries and the environment and thus may have a large impact on the urban environment.
- Local interest groups usually have different conflicting goals. For instance, actors may have different opinions regarding the “optimal” energy supply system. Also, measures on the supply-side compete with conservation measures on the demand side.
- The exploitation of local renewable resources (e.g., biomass, wind, solar energy, etc) is often expensive and needs stable, long term demand and commitment to justify the investment.

Traditionally, the approach followed to plan a LES has been to study and plan each sub-system individually and combine them, eventually, into an overall energy plan. In the case of Göteborg, four main plans have been carried out in the last 40 years: in 1977, 1987, 1995 and 1998 [Rydèn 2000].

The role of modeling in the planning process of LES in Göteborg acts as a background for the following sections.

4. Modeling as a process to make comprehensive representations.

To begin with this exploration, let us recall our hypothesis. This was established in the following way: “ICT may enrich the modeling process by expanding the boundaries of agreement”. Notice that the meaning of this statement strongly depends on how we understand the process of modeling. Therefore, in what follows, I will offer two different interpretations of this process and use them to examine the hypothesis.

This examination is pursued by addressing five questions in each case: a) what is the main epistemological assumption behind this interpretation? b) Who are the main actors involved in the modeling process? c) What types of questions are usually asked? d) What is the role of a model regarding the interactions of these actors? e) What is the relation with ICTs? The answer to these questions in each case will be illustrated (whenever possible) with instances taken from the case study in Göteborg.

I will first consider modeling as a general process to make comprehensive representations of something. This is, perhaps, the most common way in which modeling is interpreted. This common interpretation of modeling takes for granted that there is some objective “reality out there” that can be accurately represented by a model. Therefore, a model, in essence, is a ***representation*** of such a reality.

Notice that this assumption does not claim that the model is a copy of what is being modeled (as if it were a sort of a picture). Instead, it is claimed that it is possible to build an isomorphism (although sometimes an homomorphism is sufficient) between the domain in which the phenomenon is explained and the domain in which this phenomenon is observed. So, for instance, Keppler´s Laws constitute a mathematical model (i.e., the domain of its explanation) of the physical movements (the domain of observation) of the planets.

The surrealist painter René Magritte towards 1929 nicely expressed the fact that a model is not a copy of the modeled. In a famous painting called "*La traison des images*" (see Figure 1 below) Magritte made the point that any representation is an expression in a language that cannot embrace the full meaning of whatever it is trying to represent. The painting depicts the image of a pipe with a short text below that says: "this is not a pipe". This painting was the inspiration of the well-known aphorism "***The map is NOT the territory***". This aphorism can be taken as the basis for the epistemological stance of this interpretation.

If we consider now a modeling process undertaking as part of policy making in an organizational context, and we interpret modeling as a process to make comprehensive representations, then the main actors usually involved are the so-called "experts". Thus, for instance, experts in each one of the subsystems of a LES were the main actors involved in the initial modeling carried out in Göteborg during the 1970s.

Figure 2. La Trahison des images[2] by René Magritte [Paquet 2001]

2 A translation of this title could be "The treason of the images". Magritte painted it between 1928 and 1929.

Under this interpretation, when the model is perceived to be accurate enough, it is usually used to answer questions about ***optimization***. For a LES, the following is an instance of such kind of questions: "*What is the optimal allocation of resources in compliance with existing and superimposed technical, social, economic and environmental constrains?*"

When more sophisticated models are build, questions about What if? and How? become possible. In this case other ***stakeholders*** will join experts as relevant actors of the modeling process. In the case of the LES some relevant stakeholders are: political decision-makers at the local level; representatives from utilities; representatives from the municipal or regional administration; industrial energy consumers; chambers of commerce; environmental groups; and representatives from the manufacturing industry. All these people are allowed to formulate questions to the model and so the modelling becomes a ***learning process*** in which the model is dynamically adjusted.

At this point, ***understanding*** becomes more important than optimizing as a guiding principle of the modelling [Wene and Rydèn 1988]. For instance, in a LES, building ***scenarios*** is a common practice. A typical question is: "*How will restrictions on emissions of sulphur, nitrogen oxides and carbon dioxide influence the development of the energy sector?*"

However, it is important to stress here that even when we move from "an optimization paradigm to a learning paradigm" [Wene and Rydèn 1988] the epistemological stance of the model as a representation still holds. The hope of the people engaged in the learning loop is to improve the model or, in other words, to increase their understanding of what is being modelled. There is a direct correspondence between the accuracy of the model and the level of their understanding.

Regarding the role that a model plays in the interaction of participants of a planning process, using a model under this interpretation, it seems necessary to differentiate between those interactions guided by an optimization paradigm and those guided by a learning paradigm. In the first case, I will suggest that the ***mere existence*** of a model, as an abstract "thing", is enough to coordinate the interactions of participants. In this case it is usual that actors ***trust*** the model regardless their understanding. Perhaps the following short story attributed to Karl Weick [Morgan 1991] helps to illustrate the point.

This is about a group of people who got lost in a severe snowstorm in the Swiss Alps. At some point they were stranded and on the verge of giving up hope, when one of the party found a map in one of his pockets. Mobilised by the new possibilities, they mustered their energy and eventually found their way back to civilisation. Imagine their surprise, when, after their return home, it was pointed out that it was a map of the Pyrenees, not the Alps!!

In a similar way, having a model of a LES (that previously was non-existent) can create a space in which new initiatives and new actions can emerge. Without the map, the group of our story would probably have perished. However, it was not the map in itself, but so much as the certainty that they HAD A MAP, that enabled them to create the self-organising initiative that allowed a new outcome [Morgan 1991]. Similarly, the fact that actors (i.e., policy makers) in Göteborg had a comprehensive model of a LES in the 1980s helped very much to achieve an agreement around the local energy plan being proposed by experts at that time[3].

On the other hand, in the learning paradigm the mere existence of the model is not sufficient to coordinate people's interactions. As mentioned before, their coordination is triggered by their wish to improve their understanding of the system-in-focus[4]. In this case ***building trust*** in the model is an important issue of the modelling process itself. This can be achieved if the following conditions are met:

- All future alternatives can be expressed with the model (e.g., in the case of a LES a typical example is reflected in the following question: *"Is biomass a realistic alternative for Göteborg?"*)
- All questions/concerns by actors can be expressed with the model (e.g., *"What role will natural gas play in the energy system?"*)
- The goals set by actors can be expressed with the model (e.g., to increase energy conservation).

It seems that when future alternatives, current particular concerns and goals can be effectively expressed and handed by the model, actors will start to trust the model and their coordination will evolve along this common sense of trust.

Now, what is the relation with ICT when modeling is understood in this way? Well, it is clear that the computational capacity of IT plays a fundamental role here. For instance, computational tools (e.g., programming languages) to develop specific packages for economic and environmental calculations are essential in the context of LES planning.

To develop more sophisticated models under this interpretation, new programming languages are required. Packages for scenario building (like MARKAL in the case of the planning of LES) with user-friendly interfaces becomes indispensable. It seems that under this interpretation, the process of modeling does not require more particular pieces of ICT being specially designed.

5. Modeling as a process to build a common language.

Under this interpretation, it is assumed that from an ontological point of view there is no distinction between an individual observation of a phenomenon and the phenomenon itself. Objectivity is bracket and we move toward an "ontology of the

[3] Taken from an interview with Bengt Göran Dalman from Göteborg Energi AB.
[4] That is, their understanding of the system being modeled.

observer" [Maturana 1987]. Here a model is an "***epistemological device***" that is "used" by an individual to approach and make sense of the world around him/her [Harnden 1989].

To characterise this view with a similar aphorism as before, we may say that in this case "***the territory IS the map***". In other words, there is no previous territory from which we build a map to be used as a guide of our inquiries. Instead, the territory emerges as we use the map to wonder about. An example may clarify this point.

Let us consider the double-helix model of the DNA. It is clear that when Crick and Watson build and made public the model, their main concern was to offer an explicative mechanism to understand the phenomenon of heredity [Watson et al 1991]. The double-helix model was not intended to represent the structure of the DNA in the same way as an architect's model represents the structure of a building. In fact, at that time, it is quite possible that a layman would have appreciated a three-dimensional model of the DNA as a curious example of modern art. However, for the scientists involved in the search of an explanation of heredity, the view of the same model should have had produced an Eureka! Subsequent ***use of this model*** has helped in the unfolding of ***the territory*** of molecular biology as recent research on the human genome has proved.

A relevant (for our argument) follow up of this example is that the double-helix model has been popularised to the point that nowadays it is immediately associated with the structure of the DNA. It has become a ***shared model*** for a layman [Senge 1994]. Notice that now we are moving from an individual's model to a collective's model. However, in an organisational context, sharing individual models is not an easy matter, there are many individual and organisational constrains that impinges upon this [Espejo et al 1996][5].

Having being established the epistemological grounding of this interpretation of a model; let us resume our line of argument. Given a particular common topic, people may have different ways to understand, make sense, describe and inquire into it. That is, they may have different models of this situation. Understanding how these people may engage in the ***collective modelling*** of this topic is what concerns us now.

I will say that modeling in this case is the process to build a common language in which this collective can find a common ground to express their interests and concerns regarding this topic. Notice that now a model, in this more general case, is an ***"emergent epistemological device"*** of the collective's interactions during the modeling process. In terms of the metaphors used with the previous aphorisms, we may say now that, ***"the mapping of the maps is the territory"***. In other words, the territory is the collective building of the shared model.

[5] However, an explanation of these individual and organizational constrains go beyond the scope of this paper.

Under this interpretation, who are the main actors involved in the modeling process? Well, by now it should be apparent that the question itself becomes a crucial issue of the modeling process. This is the case because leaving aside actors that should have been part of the process is not only a "quantitative" loss, in terms of the information that they might have supplied to the model, but fundamentally a "qualitative" loss in terms of the constitution of the model itself (this point will be clarified with the specific example from the LES explained in the next paragraph). Therefore, part of the modeling process should include the question: Who ought to be the actors involved? Notice that this question points to the problem of establishing the boundaries of the system under consideration. This is why making this kind of question is also known as doing "boundary judgments" [Ulrich 2000][6].

But let us suppose that we have somehow involved all relevant actors in the modeling process. What could be the basis for building a common language? I will suggest that making explicit the ***systemic issues*** of the topic, that is being addressed by the collective, is a necessary condition for building as common language. To see this, let us clarify what are the systemic issues of a particular topic. Indeed, these are those issues that cannot be expressed or understood by any particular ***viewpoint*** alone[7]. For instance, in the case of a LES, the issue of building co-generation plants involves understanding relations among several parts of the LES. To be sure, a co-generation plant is a plant that simultaneously provides electricity and heat for a community. To see the point it is important to realise that traditionally there are plants that only produce electricity using different sources and methods (e.g., from coal or nuclear plants) while other plants only produce heat (e.g., from biomass waste). However, most of the methods used to produce electricity need a cooling mechanism that liberates huge quantities of energy. Usually, this energy is dissipated in the environment losing, in this way, its potential for heating and also increasing the levels of pollution. Observing the relations between electricity producers and heating producers from a systemic (i.e., relational) perspective allow the emergence of a new issue for consideration, that of the viability for the development of co-generation plants. In this way, the distinctions that emerge from considering systemic issues (like co-generation plants) may be used for building a common language among the relevant actors.

In the previous interpretation of the modeling process, optimisation and understanding were the engines of the process. In this interpretation ***co-creation*** (or co-inspiration) is the engine. This process enables developing a common systemic understanding of the topic being modeled. Notice that here the building of the (common) model guides actors' coordination of actions. People trust the modeling language being co-constructed. Building this trust is successful when the modeling language has requisite variety [Ashby 1964]. In other words, if any viewpoint's model and any systemic issue can be expressed in this language.

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6 Notice that this is an iterative process in which this question may be addressed and answered several times until some sort of stability is reached.

7 Notice that a viewpoint may refer to an individual or to a group of people sharing their models of the particular issue.

Now, what is the relation of ICTs with this interpretation of modeling? First of all, it is clear that structured modeling languages may be useful to support the process. For instance the use of more user-friendly versions of "I-Think" like languages. Secondly, technologies that help people to express their own models of a particular issue can be useful as well. For instance some tools of CSCW[8] in building cognitive maps are already available.

Last, but certainly not least, the development of ***transducers***, that is, contextual interfaces with requisite variety [Beer 1979], regarding specific systemic issues becomes crucial. This is so because, as I have stressed in this section, the effectiveness of the process of modeling under this interpretation strongly depends on the quality of the communication among the actors involved. Because these actors may involve now distant viewpoints (e.g., the people in the community of a LES), engaging them in the process surely will require the use of ICTs. Therefore, the transducers I am referring to are directly related to the use of ICTs. Let us explore this point in the following section.

6. Challenges for ICTs in supporting a modelling process.

I claim that a fundamental transducer between what I will call here the "analogue" (i.e., the way a human being relates to its surroundings) and the "digital" (i.e., the basic way in which ICTs operate) is required. I think that this gap in transduction is present whenever we deal with emotions in our communications. But this implies that this gap is present all the time, if we take Maturana's definition of a conversation as the braiding of language and emotions [Maturana 1988] and take a conversation as the building blocks of communication [Flores 1982].

Suppose that we want to make a survey to ask people how do they feel in relation to a particular issue. We want to use the answers to enhance our understanding of this issue. For instance, we would like to know how people feel regarding the energy service they have been provided locally and, of course, we would like to use this information for enhancing the modeling of the LES.

The most common way to do this sort of surveys is by dividing the issue in categories and then formulating questions whose answers should be expressed by choosing among (usually) five possible answers. In the example of the LES mentioned above, these categories could be: a) the quality of the service; b) its cost; c) the response giving to complaints; and d) the mechanisms available for paying the bills (e.g., direct debit account, pay machines, phone service, etc). The set of answers available per category may range from "excellent" to "very poor" passing through options like "very good", "good', and "bad".

There are many problems with this particular type of surveys. First, it is clear that any set of categories chosen to make the survey is arbitrary. Some may say that this is, in fact, determined by the purpose of the survey, or in other words, that this is guided by

[8] Computer Support Cooperative Work.

what the person(s) that designs the survey want to do with the answers being collected. But, of course, this is a measure of what these persons believe are the issues affecting the feeling of the people being surveyed and not a measurement of the people's feelings. Furthermore, by restricting the possible answers available to each question to five (more or less) choices, the designer is imposing again a particular way to reflect and answer the questions.

The basic flaw of this process seems to be in the assumption that emotions can be reduced to categories in order to understand them. Instead, I follow Plato's insight that emotions are not reducible. Emotions are pre-disposition for actions [Maturana 1988] and as such they belong to the operational domain of individuals interactions and not to the informational domain of their reflections [Espejo 1996]. In other words, we express our emotions in our actions and not in a rational and analytical way. So, how can we measure emotions?

Stafford Beer has suggested the use of a measure that Plato calls eudemony [Beer 1989]. To perform this measurement he developed an instrument shown in Figures 3 and 4. Figure 4 shows the reverse side of the instrument. People is shown the rotating mechanism of Figure 3 and asked to set the "meter" turning the knob until the face is coloured according to the feeling they want to express (i.e., a total orange face means "happy"; a total blue face means "miserable"). Once the individual set the "meter", the person doing the survey records the number shown in the reverse side (Figure 4). In this way this instrument acts as a transducer between the "analogue" feeling of people regarding the specific issue being questioned and the "digital" scale being used to construct a quantitative index.

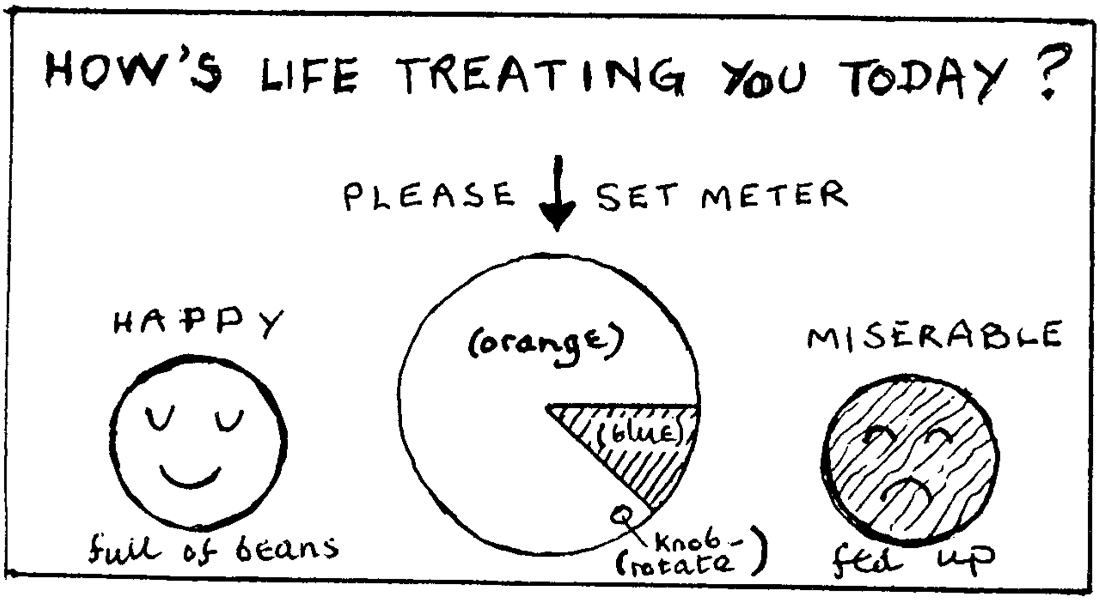

Figure 3. Instrument to measure eudemony (front) [Beer 1989]

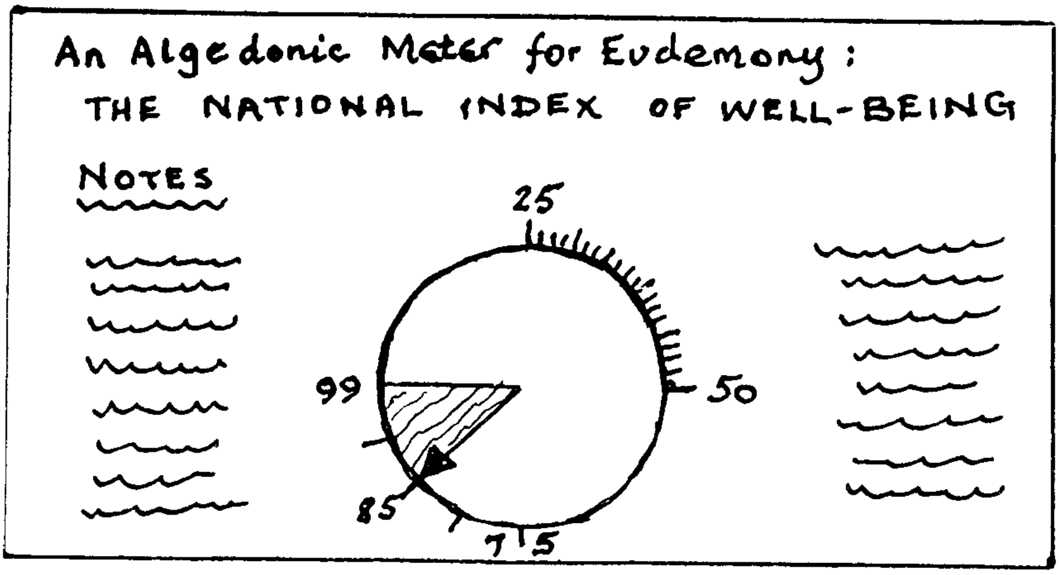

Figure 4. Instrument to measure eudemony (reverse) [Beer 1989]

But better transducers are needed not only to measure emotions but also to communicate them. The ***communication of emotions*** through ICTs is an important issue in effective communication. To fill this gap in the use of ICTs (like email and mobile phones) a set of "emoticons" has been developed. Initially these were based on typing a combination of keys as exemplified in Figure 5. However, more recently, more elaborated "emoticons" have been developed as the ones currently used in chatting systems like Yahoo (see Figure 6).

:-)	Smile	;-)	Wink
:-(	Frown	:~(	Crying
:-D	Big grin	:-*	Kiss
:-P	Sticking out tongue	:P~~~	Drooling

Figure 5. Initial emoticons

Although being an imaginative way to approach this gap in textual communication, it has the same flaw mentioned before regarding the measurement of emotions. Indeed, it tries to "digitalised" (i.e., categorised) emotions. In practice, the use of these emoticons normally triggers to the receiver only one and the same emotional state: amusement (even when the sender is using a crying face to express his/her feeling at that moment). Surely, the development of better transducers to communicate emotions through ICTs is still an open field.

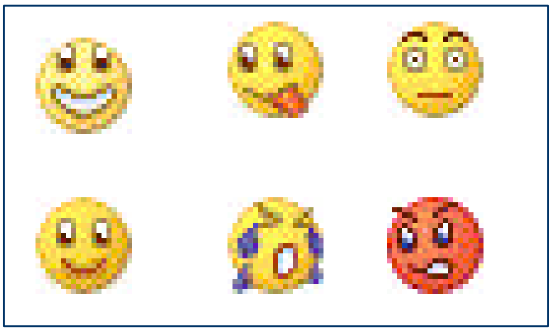

Figure 6. Current emoticons

Improving transducers for measuring and communicating emotions may enhance the process of modeling by improving the quality of the interactions among the actors involved in the process, especially among distant viewpoints. However, a final issue remains to be considered: When and on what issues those distant viewpoints should be engaged? This is a question that has to be addressed during the modeling process itself. The model developed by the Purple Group during the syntegration in July 2001 (see Figure 7) expressed this point in the bold black arrow with a question mark that appears connecting the community with the modeling box. During these discussions it was pointed out that giving a particular issue on which a wider set of distant viewpoints needed to be involved, the way ICTs should be used to manage this communication also was important. Here, more research is needed into the design of personalised navigation systems to create a space of interactions in which a structural coupling of the system and the user is possible.

7. The hypothesis revisited.

Using these two interpretations of the modeling process is now possible to review our original hypothesis. It is clear now, that the second interpretation of modeling as a process to build a common language brings to the front the need to engage distant viewpoints in high quality interactions.

The quality of these interactions will determine the quality of the modeling process and ICTs play an important role here. The developing of fundamental transducers between the “analogue” and the “digital” as regarding the measuring and communication of emotions and the design of personalised navigation systems seem as relevant areas of research. In this case, it is clear how ICTs may enrich the modeling process by expanding the boundaries of agreement.

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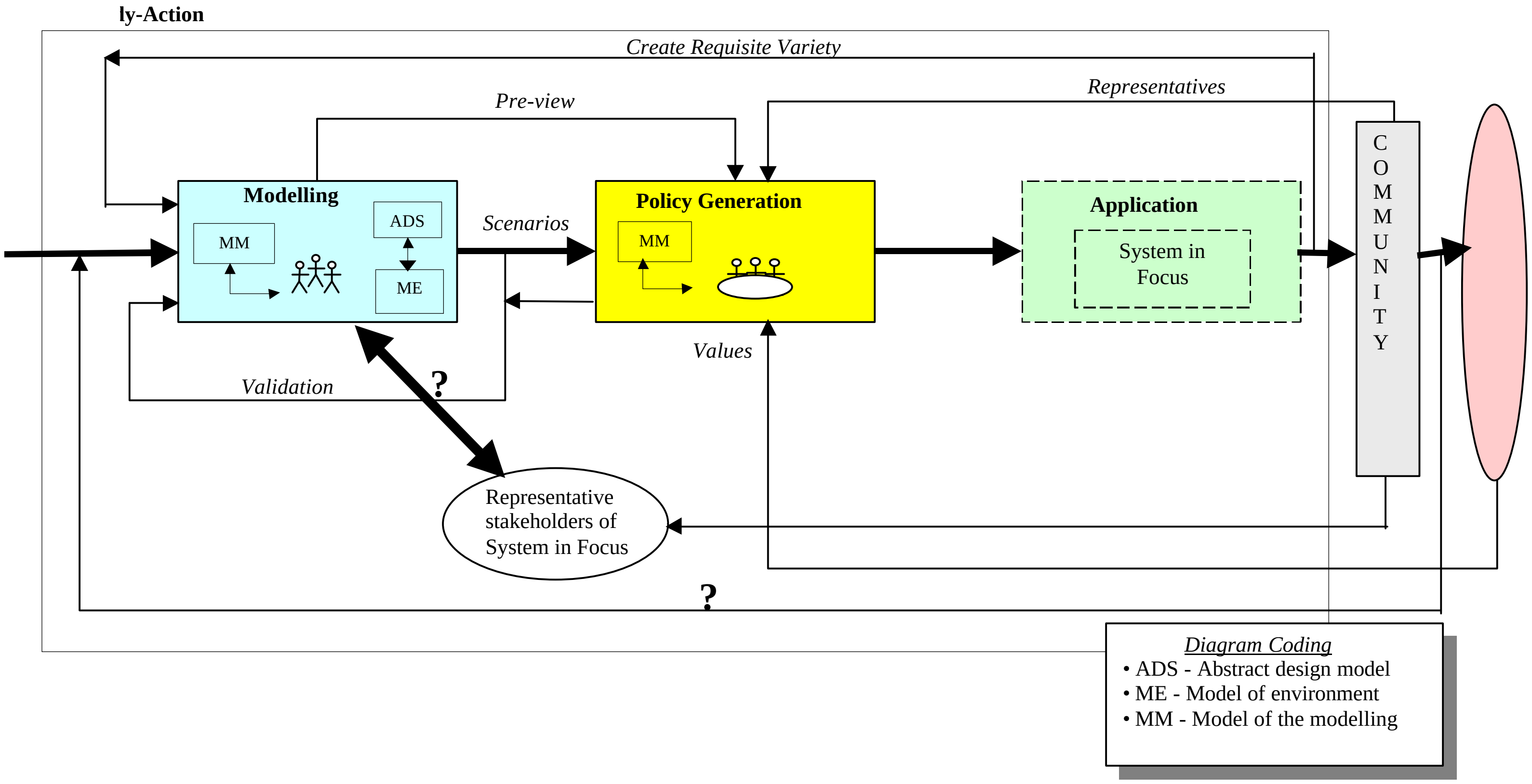

Figure 7. Model of the modeling process