Facilitating Students' Perception of Systemic Concepts through "Systemic Exploratories"

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ABSTRACT:

In order to configure more successful action in organizations, there are at least two thinkable and complementary strategies: change the conscious cognitive capabilities, or change the perception of situations; we are approaching the latter with pregraduate management students, in the context of "systemic archetypes".

First, a model of the human actor is proposed; it allows to work out a conceptualization of action, learning and explaining. Inside this framework, the limitedness of traditional approaches to teaching are shown. Then, a five-step method based upon the OMCA approach (Observe - Model - Construct - Act -) is introduced:

a) set a context and let studends describe a situation

b) make them responsible in a "management-flight-simulator" (MFS)

c) guide an exploration through the MFS's model and the archetype's generic model

d) students develop a model of their own of the first situation

e) make them compare the representations (a and d) and reflect on the differences.

1. Introduction

Systems thinking has increasingly been accepted as important part of management, and with it the idea that our default understanding in many situations we call complex, does not lead to adequate actions. There are several ways how university students may get prepared to face such complex situations. In recent years, new approaches to making learn have emerged. Also, we have learned more about human learning and its fundaments. The present work is grounded in the belief that elaborating computer simulations is a very powerful vehicle for learning, that has not been fully used as yet; it proposes a contribution in this sense.

We start with a reflection about some aspects of human knowledge in the first section, and then go on to draw up a theoretical framework in which learning appears as an activity intimately intervined with action and explaining. Section 4 briefly introduces the OMCA approach to action learning. Then we look at current educational practices and show some of their relevant limitations. The following section 5 exposes a method which cycles learners through OMCA.

2. Perception and memory

Complexity. One of the most recurrent themes in the field of systems thinking is the one of *complexity*. For instance, Senge (1990) proposes a static and a dynamic complexity. Static complexity means that the number of relevant configurations (parts and interrelations) in a "system" is such that the human observer has a hard time making himself a viable image of the "system". Dynamic complexity means that the lenght of the time interval between an action and becoming informed about its

consequences is so long that the human observer has a hard time "seeing" a causal relationship between the two events.

It should be clear, however, that declaring an issue as "complex" does not mean complexity to be an inherent attribute of the issue; rather is a judgement, corresponding to the speech act "declaration" (Winograd and Flores, 1989, Echeverría, 1995) made by a human observer on grounds of a comparison between the issue and his (cognitive) capability to "see" or "inag(in)e". Such capabilities have evolved in a hunter-gatherer environment, which has been our environment for almost all of our time on earth (Barkow et al., 1992). Only recently, in a period that is unsignificant in evolutionary terms, has our world begun to turn more complex. So we understand that we are well-eqiped only for "seeing" simple and linear relationships and causalities (von Foerster, 1988)

Perception and re-cognition. Seing situations in a way that does not take into account what a more capable observer would notice, may contribute to acting in ways that contribute to bring about states of the world that we later "see" as problems. Bohm (1981) has worked about how memory lets us *re*-present things, and how the lack of cognitive propioception leads us into exactly this situation.

Maturana (1988) shows how we only can refer to our (previous) experiences when explaining an experience, on the ground of our biologicel functioning. Weick's notion of *enactment* and concepts like "competence traps" or "superstitious learning" are well explained by Maturana: if all we have to test our explanations is the experience we make when using the explanation, then any explanation that does not lead to a surprise is valid, and only self-deceiving processes of blinding out experiences may be dangerous (which means that in principle, there may be more than one valid explanation).

Tacitness. Polanyi (1983) argues that whatever we explain with explicit reflections arises above a tacit knowing which is already there before the explaining, and which has come about without a need for explaining. According to this, a manager knows the situation before being able to explain it.

In a similar way, Maturana (1997) shows how experience "happens" to us; life as the biological flow of changes happens to us and does not need explanations to happen. However, a particular way to explain our experience is always a particular course of action that triggers a particular flow of internal changes; in other words it changes the course of life, and by this argument, explaining (imaging) does become vitally important. It follows that explanations are not what they refer to, but become part of what will be explained in the future.

Approaches to overcome our limit (though not our limitedness). If we diagnose that our usual (default) way of perceiving/re-presenting situations or systems is poor, we should feel invited to suggest a way to improve it. In order to do so, we may first decide to either

- intervene inside the context of particular situations (take situations as particulars), helping the perceiver to elaborate a viable image above an unchanged tacit knowing
- intervene at a deeper level of perceptice processes, such that the perceiver will tacitly "see" something different *before* explaining.

The case of systemic archetypes. Arrived at this point in the argumentation, I call "systemic archetypes" onto the scene. They are frequent -therefore archetypical- configurations built of combined, closed loops of positive and negative feedback with different time horizons (delays as told from the standpoint of a single observer who goes by the tact of the shorter loops). "Seeing" an archetype by default or

constructing its image explicitly upon a distinct perception are two different things when we judge by the effort of attention and time needed to arrive at the image (understanding).

Systemic archetypes have been called into question (Sterman in Senge et al., 1995) for an alleged danger to "snap" mental models onto unjustified structures and thus avoiding sound inquiry. However, on the ground of the points made by Maturana and Bohm, as well as our own model (Schaffernicht and Pereira, 1998), this is in itself a questionable objection. If perceptions are constructed by the observer (re-presented by referring to previous experiences), then any perception -the initially problematized linear one as well as the systemic one- is a "snap-on" default knowing (in the sense of Polanyi); both are legitime in referring to memorized experiences they refer to, and both are to be questioned as for the viability of the actions they allow.

And this leads to the only difference that may exist between them: their respective explanatory and operational coherence (Schaffernicht and Pereira, 1998), which can only be assessed by acting them out. In other words: the viability of perceiving linear "laundry list" configurations or systemic archetypes will only surface in the success or failure of the actions carried out on their grounds. Consequently, while those who caution against a lack of conscious reflection are always right to do so, this should not make anybody think that perceiving systemic archetypes instead of laundry lists would not be an idea worth trying (after all, the fact that the systems thinking community puts great emphasis on the shortcomings of linear perceiving already (tacitly) makes the same point.).

3. Action, Explanations and Learning

In order to reflect on how we may facilitate a change in perceiving, we have to make explicit some points about learning and closely related concepts. Of cause, there are many definitions of "learning"; some stress new behavior or a successful resposne to new stimuli (March, 1991), others draw a closed loop with aptitudes, attitudes and beliefs (Senge et al., 1995). Evolutionary psychologists (Barkow et al., 1992) stress that new behaviors or capabilities that an individual displays at some point in the course of his life are not "learned instead of innate"; rather, the individual started existing with a particular configuration that made possible the inner changes in the course of which these new capabilities appear; learning thus appears as inner reconfigurations that occur according to the individual's (inter)action with the medium it is distinguished from.

Maturana's model of the human being (as well as our own one, that draws heavily on Maturana's work and is explained in Schaffernicht and Pereira, 1998) shows how action and learning are related: the nervous system and the rest of the body (muscles etc.) operate as two operationally closed dynamic systems that intersect in the receptors and effectors. As a consequence, the human being cannot act (move the muscles) without triggering chains of transitions of state inside the nervous system (however, such chains of transitions can also be triggered by other events, internal to the nervous system). Additionally, many chains of transitions finish with muscle movements. Thus the nervous system follows and configures correlations between stimulus and response, according to its particular structural configuration in the moment, which allows the human (living) system to co-change with its medium in a coherent course of transitions, in other words: to stay alive. This means that one cannot exist without (inter)acting (with the medium), and one cannot *act* without *learning* (remind Bateson's ideas about higher levels of learning), when one accepts learning as the internal changes that redefine the possibilities for action.

The role of *explanations* in the proposed conceptual triade can be seen in that the human actor *observes*: we elevate parts of our operating as biological units into the domain of language, in which arise awareness and our proper existence as self-conscious persons, thus explaining the world and the life that happen to us (Schaffernicht and Pereira, 1998). As Maturana remarks (1997), what is explained by an observer has already happened, independently from his explaining, but the explaining is part of shaping the future (as stated in the section about tacitness).

Explaining as a particular form of acting is thus linked to learning, and it can be used to escape from learning traps, since it allows for multiple recursive levels of explaining/validating (Schaffernicht and Pereira, 1998): for each explanation A one can specify an explanation B that shows how to see the validity of A; then, action can generate the observations that allow to maintain or improve A, and so on. Surprises generated while observing indicate limits of coherence of the corresponding explanation. Each explanation can be thought of as having a particular domain of explanative coherence (surprise-free action), and so distinct explanations will have distinct domains of coherence. We can then try to assess these, and select alternative explanations according to how attractive we judge their domain of coherence.

We can conclude here that while learning is possible without explaining, the latter enhances the power of the former, if properly used. So we posit that acting, explaining and learning can be separated for analytic purposes, but shall appear together when reflecting upon real-life issues.

4. Observing, modeling, constructing and acting

Observing, modeling, constructing and acting are four types of action that, combined in iterative loops form the OMCA approach (Schaffernicht and Pereira, 1998; Schaffernicht, 1999). We propose this generic process as means for joining action, explaining and learning in persons and in organizations, since it enables single-loop and double-loop learning. Here, we give an abrieviated definition of each of these actions:

Observe

- Function: to raise distinctions form the tacit level into the explicit domain of explanations (basic explanations as well as validation criteria)
- Function: to learn to observe
- The quality of observing defines the possibilities of later steps: what is not observed cannot be designed

Model

- Function: to generate an exhaustive, cohesive, non-redundant an explanatorily coherent system of explanations
- Function: to learn to model
- Causal mapping and "systems dynamics" simulation help to obtain internal and historic coherence
- what has not been modeled, shall not be constructed

Construct

- Function: to generate artifacts (methods, apparatus) that allows to act out and test the models
- Function: to learn to construct

Act (and Observe)

- Function: to intervene in situations/target-systems such as to obtain desired changes

- Function: to obtain observations
- Function: to learn to act with a higher degree of awareness

5. A brief revision of current approaches to making learn

Based on the previous concepts, we can now examine various of the currently dominant approaches to teaching in Universities: reading (a textbook), working through a case, dialogue, training of new behaviors, making experiences/experiments, using management flight simulators (MFS) and using microworlds

Reading a textbook is clearly intended to occupy the reader (mentally) with the book's conceptual content, and indeed it may bring about some form of insight, provided that the reader has previously made some experience on which such new understanding can shape. However, the action of the student is "reading", and consequently the experience and associated learning refer to "reading" more than to the content read.

Working through a management *case* is somewhat closer to the action of "managing" as converting between action and information (Forrester, 1994), in that information is needed to devise actions to be taken (deciding); however, the choice of information sources and interpretation processes is not free (as it would be in a "real" management setting). Also, devised actions are not carried out, and thus the actor/student cannot become informed about possible surprises generated by his personal explanations he uses to design his actions. Again, our theoretical framework suggests that learning through cases will not complete an OMCA cycle.

Dialogue, as developed by Bohm (1996) and similar approaches (such as Maturana's cognitive therapy) helps generate possibilities for *presenting* oneself a new understanding insead of *re*-presenting from past thoughts. It has to come toghether with a genuine commitment to action, but it clearly is a way to arrive at a new way of "seeing". However, it is slow to work, and being in a hurry seems to be one of the best shared situations in today's organizations; if we like it or not, many people do not take themselves the time needed.

Training of new behavioral patterns includes action and generates new practices, and according to what we posited above, distinct acting triggers distinct learning. So one might trust in that new thinking and learning will trigger new attitides and awareness. However, actions have not been designed by the actors, and additionally, the time needed is rather long, especially since there is no big support for conceptualizing the new experiences.

Making proper *experiences* is obviously a powerful way of generating full, provided we do it in ways that benefit from surprises, instead of deceiving ourselves. However, it is also a rather costly approach, since "real-life" management surprises may cost a lot of money to overcome and may prove unrecoverable.

A *MFS* may well enhance a management case, since it allows acting and seeing the consequences, and in this they are much richer than confronting the student's opinion with the leacturer's one without being able to simply try them out. But they do not include "constructing" nor "modeling" (in the OMCA terminology). The user may develop a tacit mental model of what he is using (the simulation model), but using the MFS does not comprise the design (observing and modeling), construction and action/validation of an explicit model. This matches the limitation of the metaphor: aircraft trainees fly aeroplanes, they do not design or construct them; however, managers do design and construct organizations.)

Both of these activities are important in the domain of "microworlds". Papert (1990 a, b, c) has worked out his theory of learning as constructing knowledge about

the domain in which one constructs something, parting form Piaget's constructivism, and laid out the fundaments of these worlds that someone designs as a reduced version of another world, in order to allow its visitors to develop understandings that are new (at least to them). He uses computers because of their simulation capability, and because programming them is "learning-by-explaning" (and probing your explanation) -as I suggest- in cycles of OMCA (note that MFS are not full-fledged microworlds in this sense, since they exclude the constructing phase and leave the modeling phase up to the user's iniciative). The unconvenient observation about microworlds is that they demand a lot of time to elaborate the computational environment in which they operate, and often the users have to know how to program a computer in order to use them.

However, out of the approaches we have looked at, microworlds are most interesting, also because of one specific feature we will examine now.

Exploration, construction and mediation

In a microworld, the user can re-invent concepts that the designer has "hidden" there; for instance, the famous LOGO programmimg environment and its successors have allowed to "explore" systemic concepts by "constructing".

"Exploring" is an activity that results in knowing how something is, implicitly assuming that it is already so before you come to know it. In opposition to this, "constructing" is an activity that results in having built something that did not exist before. Both of them are seen here as complete OMCA cycles: *exploring* is acting in order to know, and can hardly be done without observing, modeling and constructing; constructing passes by acting. observing and modeling. The third concept - "mediation"- refers to when a teacher or coach leads the learner in connecting an experience to a specific concept.

Let us now posit that the appropriate design of learning environments will use OMCA cycles that from the viewpoit of the learner are a construction process, and from the designer's standpoint an exploration process, meant to shape certain understandings/capabilities, and occasionally mediated by a teacher. This is a way to combine acting, explaining and learning according to our theoretical framework. Microworlds can be used to do this. but we think that our intention to facilitate the perception of systemic archetypes in certain situations can also be reached with combinations of other elements that satisfy the mentioned criterions: a mediated construction/exploration in form of OMCA loops. The remainder of this paper deals with one way of doing so.

6. Five steps for changing a perception

6.1 The general method

The following explanations describe this approach in rather general terms, that *might* be used with a variety of (not only) systemic concepts (I put emphasis on the "might": currently there are no validated experiences concerning such uses); here we present the case of one systemic archetype (in which the "iThink" software of High Performance Systems was used).

The method proceeds in five central steps that articulate an OMCA process:

1. *Observing and Modeling*: introduction and setting up of a situation inside a (hidden) context, which the students know from their experience, and which they freely describe
2. *Acting and Observing*: the students act in a business simulator; the situation they act in corresponds to a different setting in the same context, so that their acting

corresponds to their way of explaining, and will generate some surprises.

3. *Modeling*: mediated exploration of the simulation's model and the corresponding archetype's generic model; the students come to see how the game could be explained in order not to suffer surprises, and why this was the case.
4. *Modeling, Constructing and Acting*: design and construction of a simulation model inside the initial situation, based on the generic model; the students engage in constructing with their new ideas, and in order to make the model simulate well, thay have to develop an operationally sound understanding of the archetype.
5. *Comparison* of the descriptions and reflection on the results; the student's model is a new way to describe situations in the same context, and so everyone can now see if the student's way to "see" this context has changed during the work. If so, he or she can now reflect on what has changed in him/her.

This cycle of five steps is consistent with OMCA and the theory we develop and follow, and it is designed to overcome the mentioned limitations of the previously revised approaches. The learning environment thus designed and constructed recieves the name "exploratory", because the students who work in it explore concepts we have hidden in there through a mixture of construction and mediation; they re-invent a systemic archetype.

6.2 A concrete case: the "limits-of-growth" archetype

In our first exploratories, we have selected two *systemic archetypes* for their particular relevance for the management of firms in Chile: "limits-of-growth" and "quick fixes that backfire". These exploratories now become part of the course about systems "theory and practice" for students of management science. Here, we present the principal traits of the first exploratory's simulation models, together with some information on its use.

The limits-of-growth deals with situations where two growth processes of different speed create a tension for a decision maker. On one hand, growing opportunities gives rise to the wish to take them. On the other hand, capabilities have to grow, too; now if these depend on two resources that grow at different speeds, then the slower one will determine the speed of capability growth, but often the deciders do not conceptualize the two resources such as to discover the tension. An impressive example is the rise and fall of People's Express airline described in Senge (1990).

Let us now look at how the users explore this.

In the first step, the students are asked to figure out what to think and to do as consultants of a university that has to decide if to set up a new undergraduate carreer or not; there is plenty of demand amongst young people, and few universities have gone for it yet. The university has finance, however there are few qualified professionals to hire as lecturers. So one issue is if they shall do it with the professionals they can get and accept low-profile lecturers, our let it pass, risking that other universities might start before them and take the market.

After writing down their ideas (during about one hour), the users go on to the simulated company.

The business simulation for step 2 has a rather simple interface, that divides the screen into four parts:

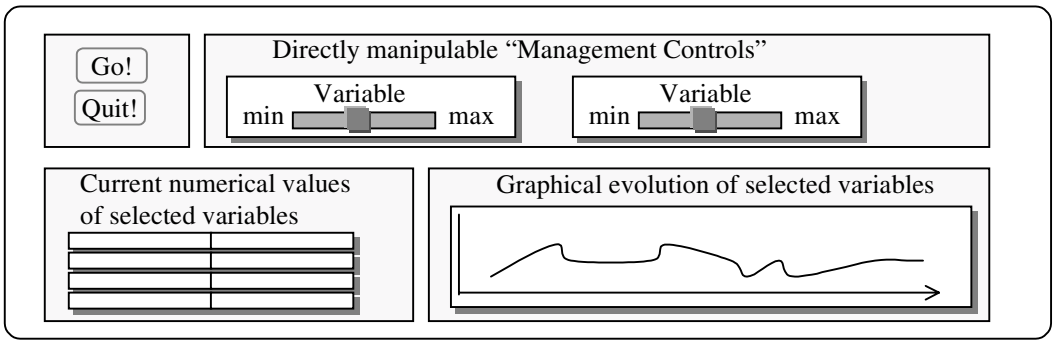

Fig. 1: Interface for the simulator of step 2 - abstract vision

In the Go! and Quit! part, the user/learner can tell the software to go one (initial or more) step in the artificial company by clicking on a Go! button. After performing the step, the system pauses, awaiting the user to do all his reflecting and modeling. A click on Quit! stops the "flight".

There are several vriables that change value under direct influence of the manager; for each of these "cotrols" of his company, he has a "management control" in the simulator. Go!-ing results in changing a set of variables that are reckognized as relevant, but beyond the manager's direct control; these are displayed in numerical format as current values, and plotted as lines in a graph-pad in order to give a vision of the dynamic evolution of the company.

In our specific, the company is not a university (we change the setting, but not the context) but any industrial factory that uses workers and machines to produce output (each individual product is made on demand). Prices and wages are fixed, only quantities may change. The manager observes the demanded quantity of products, then decides how much of the demand to accept, and can calculate how many workers and machines he needs. With a given set of workers and machines, there is a maximum quantity of products feasible with perfect quality. This means, if you accept to produce beyond this number of products, quality will go down.

This is the information users are given, and this is what their „office" looks like:

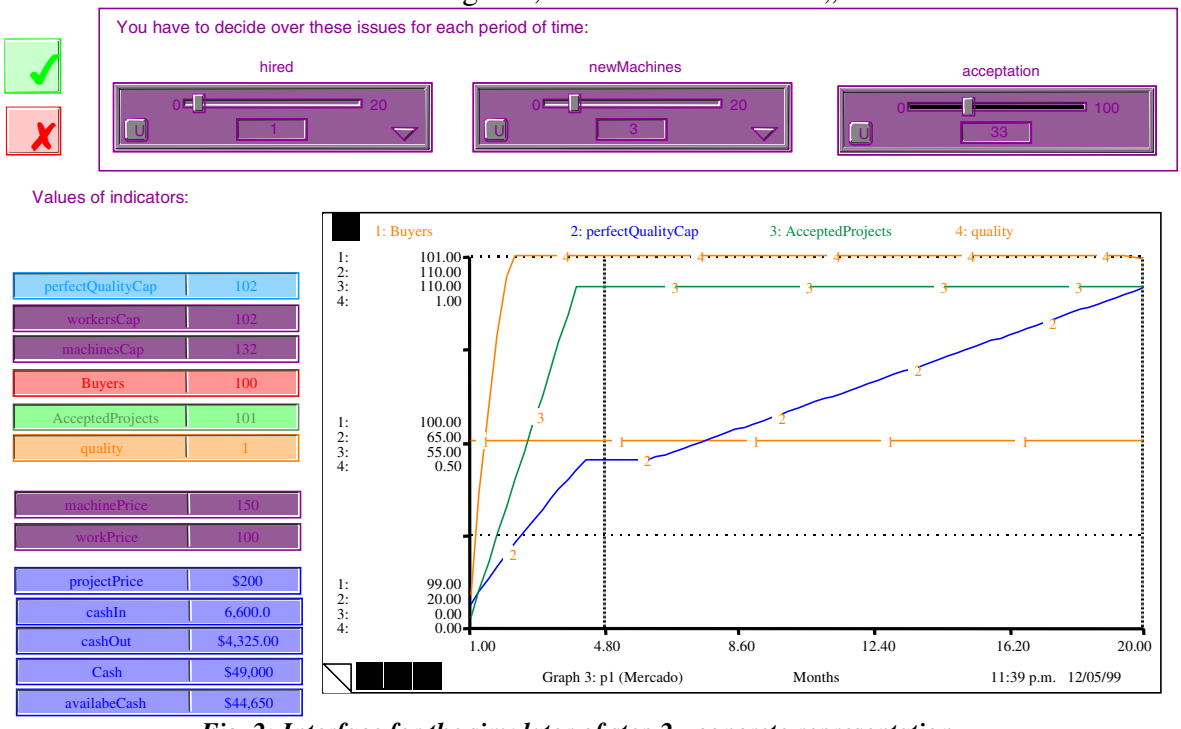

Fig. 2: Interface for the simulator of step 2 - concrete representation

There are three „management controls“ to tune: hiring new workers, buying new machines, and the number of accepted projects (less or equal to the demand). Essential variables are displayed in the lower region of the screen (the graph pad has various pages), and users can open a table to track de variables‘ evolution in numerical format.

Now the user/manager sits in front of his control screen and has to start taking decisions; after each decision, the consequences are displayed, and their discovery triggers reflection and the design of new decisions. Since the company‘s model is unknown to the „managers“, the ideas they brought with them come to a test, which triggers surprise and discussion amonsgt them. Discussing allows to unearth chunks of knowledge that would probably be held private when talking with the lecturer; so the lecturer and his staff are well-advised playing the role of observers during this step.

However, there comes a moment when they feel that it‘s time to open the black box; the observers turn into mediators and start a guided tour to the model, which looks like this:

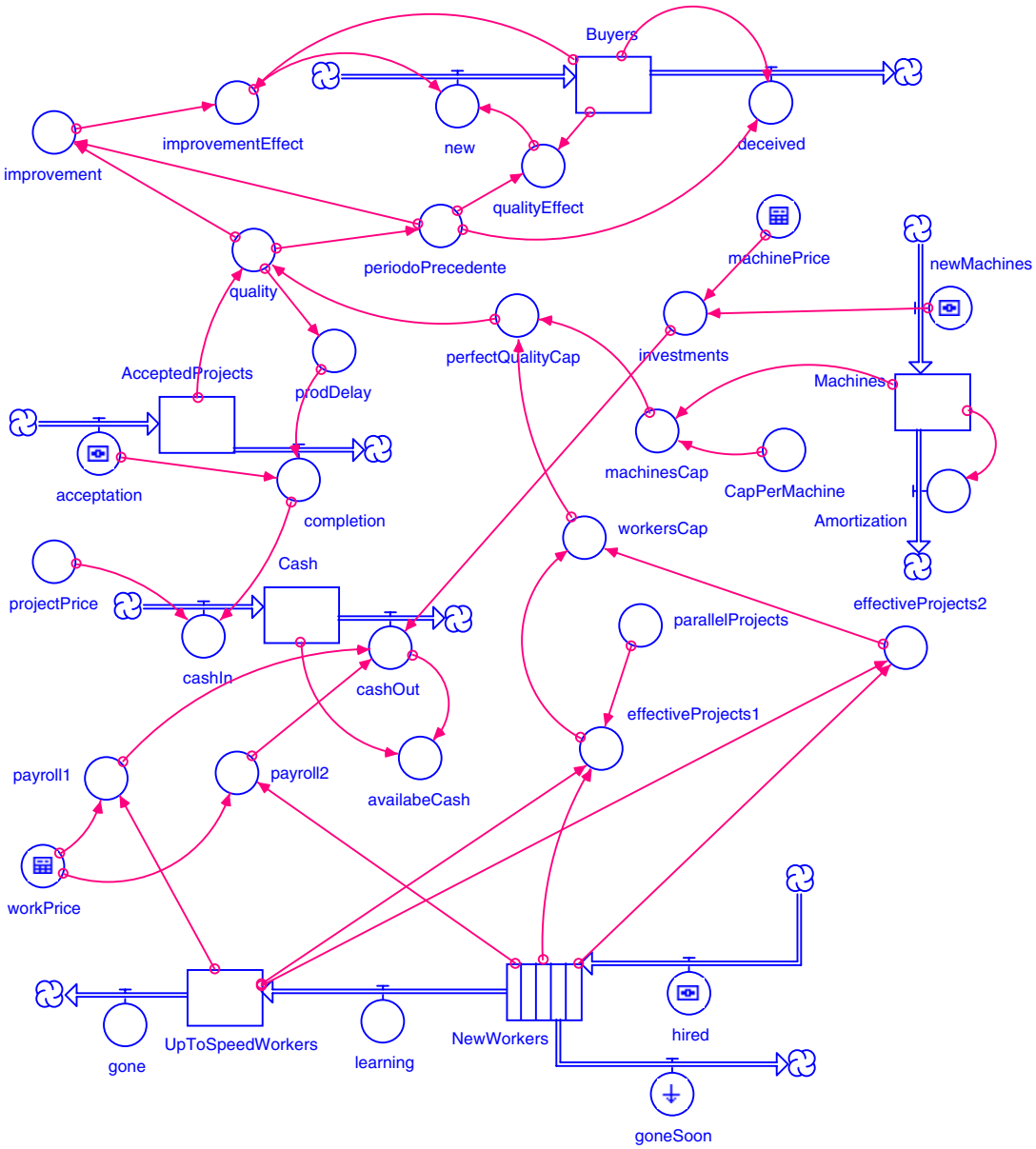

Fig. 3: The step 2 model for exploring in step 3

The first flow represents the buyers, and in each period some may arrive or leave. New ones arrive depending on the past quality and its tendency (it may have been poor, but improving). Quality depends directly of the relation between the production capacity and the number of accepted projects (which are represented as a flow with „accepted“ as entry and „completed“ as exit). Just below the projects flow, the money flows (in for completed projects, and out for machines bought and workers on payroll). Machines (on the right side of the model) start working immediately and lose value as a fixed fraction of stock. In the lower region of the model is the flow that represents the workers; recently hired workers have to step through a learning process before becoming fully productive.

This is what makes managing the company hard: you can buy machines today and they will be productive right away, but the workers you hire will be productive after tomorrow. So managers who accept all and hire have to discover that quality takes a nosedive, and this is precisely what the archetype is about.

Now the same archetype can be modelled in a decontextualized way, such as to represent kind of a template. This generic model explored in step 3 (which is the starting point for constructing in step 4) is somewhat simpler (next page). It distinguishes an external flow from the universe we are looking at; we may attract individuals belonging to this universe and make them appear in an external indicator that shows our market opportunities; however, deceptions they experience with us may also make them go away (and those who part never come back).

On the other side, there is an internal indicator, that has to do with our possibilities as expressed by two different factors; this indicator can be compared with the external one (the idea is to make possible internally what is needed to take the opportunities). In response to the comparison, corrective action can be taken on the levels of the two factors. However, action and effect are two distinct things, and in the two factors, the effects do not come about with the same speed. This is why the internal indicator will not respond with the speed that will be desired by looking at factor 1, which is exactly the archetype‘s trap.

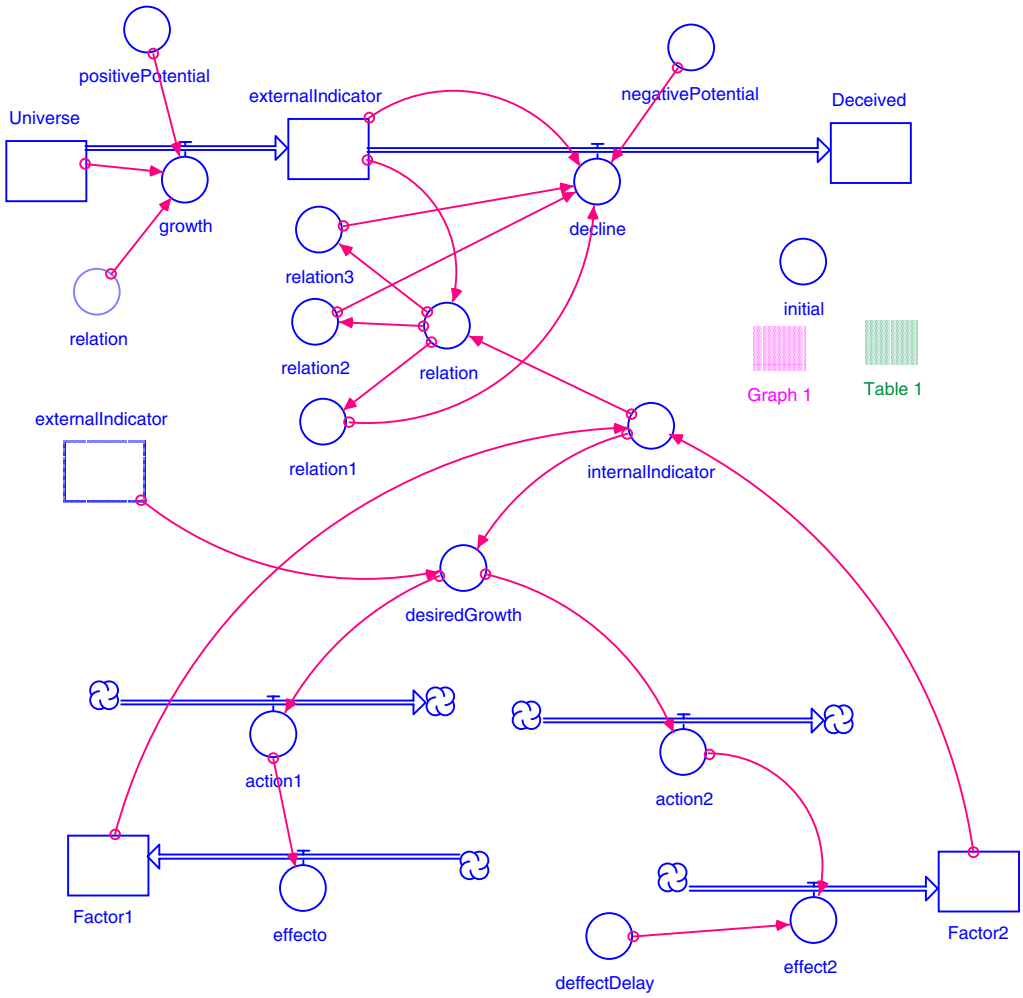

Fig. 4: The archetype's generic model

After this guided exploration, we go back to our university (the setting of step 1), and ask the students to model the case, based on the generic model. This makes them use the new ideas (rather that the ones they brought with them in the beginning), and simulation allows shaping coherent ideas. Finally, they are invited to look at the descriptions they had initially made, and complete them (modifications are allowed, but they must not make disappear what has already been written down). Do they see things differently now? What does it mean?

Students who have used this exploratory do see things differently now. We do not know what this will mean to them in practical terms, for now it is part of their experience. However, we believe that the internal confrontation with two different perceptions is an enriching experience.

Despite our first encouraging experience, it is important to stress that this has to be taken with precaution, for various reasons:

- actually we do not know if the idea is transferable to ideas other than systemic archetypes;
- also, we see signals indicating that the concrete form of our two exploratories is not definitive, since we have had to adjust the „manager‘s interface“ to different users. This may mean that there may not be one single interface (it has to be adjusted to various types of users), or it may mean that it takes more tries to

stabilize it.

- on a deeper conceptual level, this may also mean that the setting must be adapted to each group of explorers: what seems a success with university students may be inappropriate with management professionals. This would mean that the initial setting we used is only one of a –still to be established- family.

Clearly, more practical testing is necessary in the domain of what we call exploratory; however, the first steps in this direction have been encouraging.

7. Conclusion

In this work, we have started from two possible strategies to enhance our capabilities in situations we usually classify as complex: post-perception analytical training and an intervention at the tacit level of perceiving. We have preferred the latter strategy, introduced reflections on the subjective nature of complexity, perception, re-cognition and tacitness, and then presented our theoretical arguments in favor of uniting acting, explaining and learning. We could then revise the principal approaches used today in management education and show their respective limits. Introducing microworlds, we could also show the benefits and limits of the "management flight simulators", that have to do with the concepts of exploring, constructing end mediating. On the grounds of these reflections and the OMCA - approach, which has been introduced briefly, we have proposed a method that generates "exploratories" based on constructing and mediating. Initial empirical data suggested that this is a promising approach, and we can call for more exploration and inquiry.

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