The importance of 'presenting' knowledge:

The role of the teaching environment in the Allosteric Learning Model

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The aim of this article is to understand how we learn, how we use our conceptions and representations to construct our own knowledge, and how the latter may sometimes become obstacles to learning.
Working with the Allosteric Learning Model and the teaching environment it recommends, we illustrate some of the parameters of the *learning process* via scientific experiments, which can be used to teach science in classrooms or to general audiences. We also recommend creative ways of turning classes more attractive in order to arouse the pupils' curiosity and critical mind, and to a broader extent, to give them *appetite for sciences*.

Introduction

Much too often, teachers and popularisers remain convinced that they just need to explain, show carefully, repeat, ask to handle, even reward or punish, so that the pupil can learn. Yet, it turns out that such practices are far from being satisfactory in order to ensure the building of knowledge and skills on the long term. How come? Simply because many parameters intervene between the transmitter (the mediator's brain) and the receiver (the learner's brain).
The latest research in science didactics conducted in the Laboratoire de Didactique et Epistémologie des Sciences (LDES) at the Geneva University, directed by Professor Giordan, shed a particularly bright light on the issue thanks to his learning model named *Allosteric Learning Model*. This article refers to these numerous works. It comes divided in two parts. On the one hand, it offers a sample of the allosteric model and his mechanisms. On the other hand, it describes the parameters identified as favourable for learning, gathered under the label *didactic environment*. These latters are illustrated by experiments of physical sciences, a perfect approach of a fictitious string of teaching, focused on *levitation*.

PART ONE – LEARNING AND THE ALLOSTERIC MODEL

How do we learn?

It is a known fact that the child doesn't come without knowledge at school. He already has a background made out of his experience of living in the different environments he/she moves. Be them natural and geographical, domestic and affective, religious, cultural, and socio-economical. All these elements find their roots in social paradigms and values, but also on empirical knowledge, which will mould and stamp the ways of thinking, reasoning, understanding, interpreting facts and so on and so forth.
This perception of the world is expressed through behaviours, body movements, moves, presumptions and beliefs, named by the researchers *conceptions*. These conceptions are not merely mental images, but also the ways of reasoning they carry with them. And together, they allow the individual to make sense out of the world that surrounds him/her.
Still, the conception is not just this visible part of the iceberg (see figure 1). It is not '*the product of the mind, it is the process itself of the mental activity. It becomes an approach, both mental and behavioural, that the learner manages in order to regulate his environment*[3]'. Therefore, we can

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find its roots in the senses, the affect, the emotions, epistemology, concepts or semantics. Seen as active processes, the conceptions allow the identification of situations, be them new or not, by prompting existing knowledges. And this is where they become a major tool for any new acquiring of knowledge.

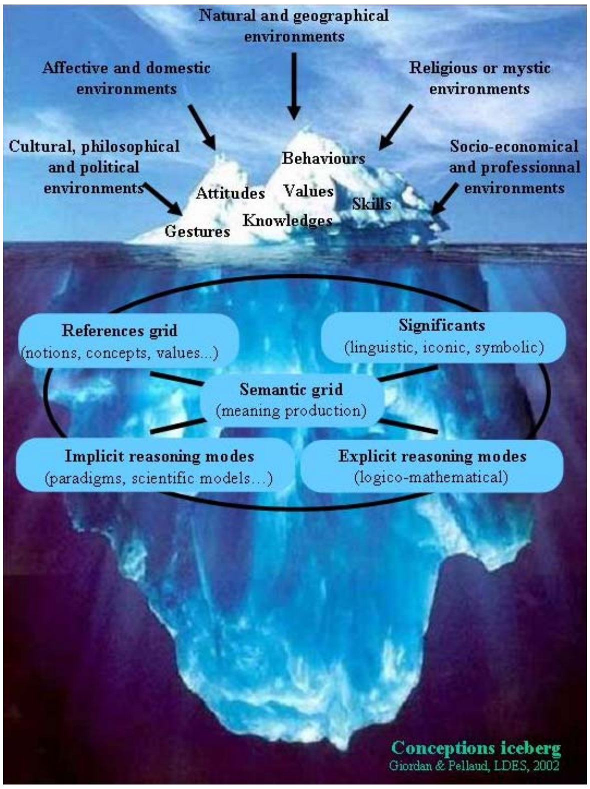

Figure 1. Conceptions iceberg.

Nevertheless, even if these conceptions are crucial to allow vital links between the existing knowledge and the one to be acquired, they can soon become an obstacle to the *learning* the way Bachelard (1938) intended it. They might as well act as shrinking filters. Indeed, submitted to the explanatory system of the learner, the new piece of information will more often than not be interpreted, distorted by the system, to eventually adapt to it. If the adaptation cannot happen, the piece of information will just be rejected. (see figure 2).

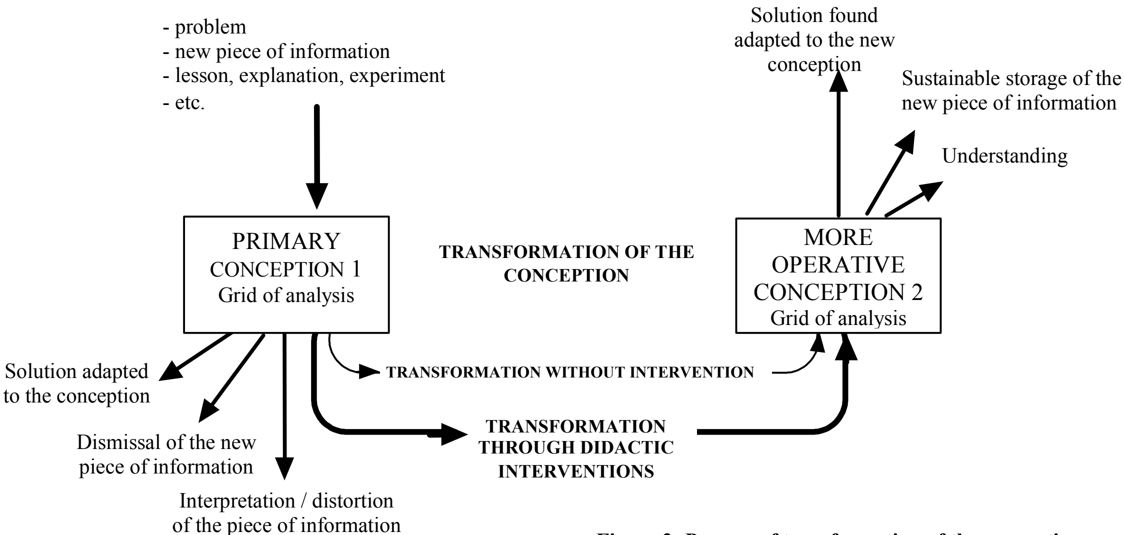

Figure 2: Process of transformation of the conceptions
Giordan, Pellaud & Eastes, 2002

The only way a piece of information can make its way directly, it has to echo with the whole existing knowledge of the learner. It also has to find itself in what Vygotsky (1933) called the *Zone of Proximal Development* (ZPD). Yet, this can only work for a very small percentage of pupils. For all the others, it is important to bring to play what we call a *didactic* environment, relying on the conceptions in order to outmatch them. This didactic environment allows a transformation of the existing knowledge by means of deconstruction – reconstruction, giving the learner the opportunity to implement a real learning and a sustainable storage of information.

What is a didactic environment?

The didactic environment is the whole of the elements and methods that the teacher must put at the learner's disposal in order to try and favour the transformation of his conceptions. We use *try* on purpose for, as Giordan (1994) and Meirieu (2001) point out, '*the pupil alone can learn, and no one else can do it for him/her'*. On the other hand, both of them also specify that '*if the pupil alone can learn, he/she cannot learn alone*'. This is where the major role of the teacher, or in a broader term the mediator, comes into play.

The parameters given below (see figure 3), intervening in the act of learning, are only useful if they interact with one another. Indeed, it is facing variety that the learner stands more chances to build his/her own knowledge. This is why they are shown in the form of a concept map and not in a linear form. The concept map is a very useful tool to develop systemic thought as well as global and complex approach that are needed to face and grasp the present problems.

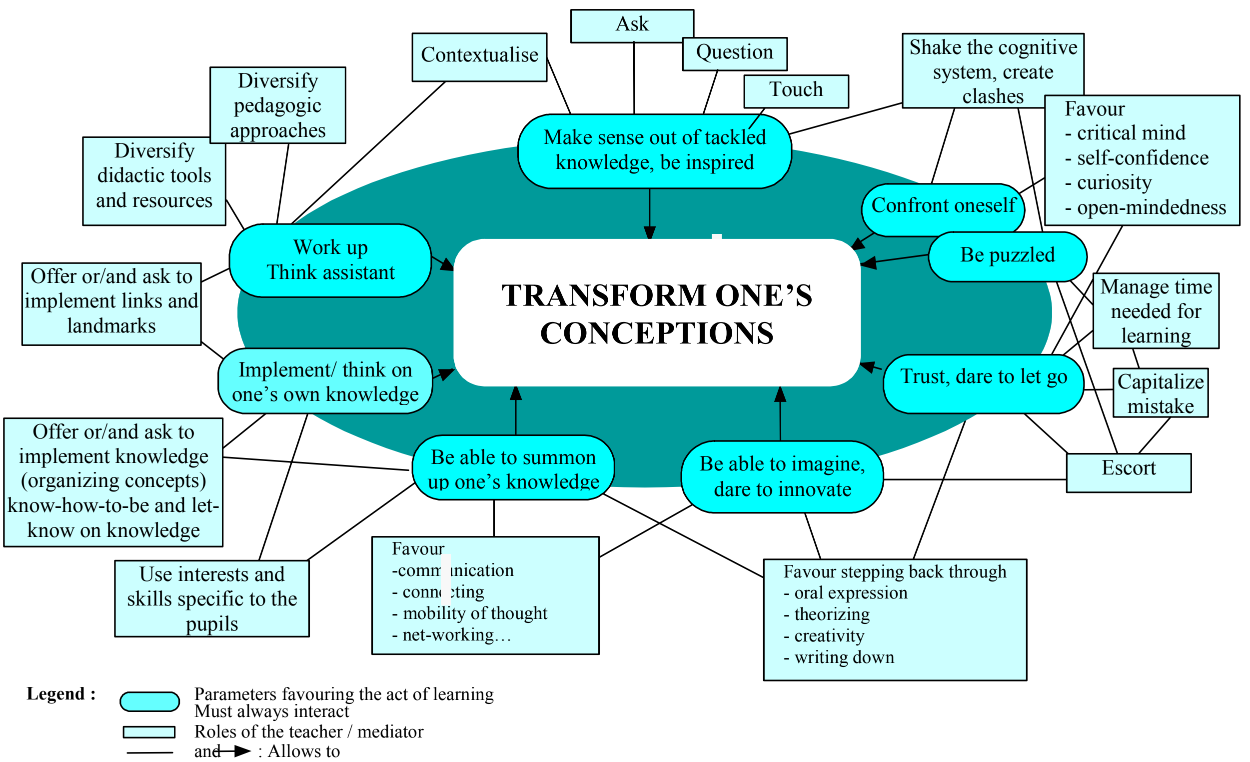

Figure 3: Didactic environnment favouring the act of learning
Giordan - Pellaud (2002)

Among these parameters, eight of them refer to the opportunity that the pupil must have to do, be, realise, or think. The other items refer to the role of the teacher/mediator and what he/she can specifically bring, linked to his/her pedagogic and didactic objectives. Throughout the second part, we present a detailed study, which examples are taken from the following sequence of scientific mediation (text box 1).

Text box 1. Levitation: progress of the sequence

The levitation theme allows to tackle a great number of notions related to a large variety of fields of physics. It also allows to link them to the everyday life of the learners, be them pupils or an audience from a popularisation project.

The mediator arrives juggling with three balls, hence placing himself/herself right from the start in a playful and dramatic approach. He/she explains that he/she tries to maintain them *hanging in the air* as long as possible but, as one of the balls falls, he/she is put off and admits to be powerless: all things must fall…

Follows a discussion brainstorming-like, where he/she asks the audience about the different means one could imagine to prevent the object from going *down*, when they are not kept *high* by touch.
This is the perfect time to define the useful terms (mass, gravitational attraction, weight, *up* and *down*, gravity, weightlessness, levitation…) and to rise up the audience's conceptions on these subjects.
He/she then tries to come up with a collective definition of the word *levitation* until it bears the two following ideas:

- The height of a levitating object must be kept steady over time;
- No solid touch must be exerted upon it.

Guided by the mediator, the audience has to manage to distinguish, according to the definition stated above, three kinds of forces capable of ensuring the levitation of an object:

- Inertia forces (satellite, bullet, spinning top…)
- Forces linked to the movement of the object or a part of the object (plane, chopper, Venturi effect…);
- Static forces (permanent magnetism, electrostatics, Archimedes' principle…).

Given the possibility, some ideas (terms between parenthesis above) will be illustrated by different spectacular experiments that will implement the many characteristics of the levitation phenomenon.

Obviously, this sequence can come in many shapes and last different length of time, whether it is shown with teaching or popularizing views in mind. By and large, it allows nevertheless an implementation of multiple knowledges centered around a well known phenomenon, that definitely carries much interest.

PART TWO – TO TRANSFORM HIS/HER CONCEPTIONS, THE PUPIL HAS TO:

Make sense out of the tackled knowledges, be inspired

Where do the interests of the learner lie, according to his/her age, background, existing knowledge and past experiences? Obtained through dialog, and to a larger extent, with the establishment of a relation of trust with the learner, such indications are vital in giving the teacher remarkable leads to follow. He/she is thus able to contextualise the subject, and ask questions that, while being within the pupils' reach, arouse interest and curiosity, and that eventually urge them to go *further*. Thanks to them, the pupils will be both concerned by the subject at hand and sufficiently challenged to outmatch their conceptions.
Several leads are possible, and the sequence shown in text box 1 gives us some examples: the teacher can start from the mere observation of daily phenomena, be them impressive or not. *Levitation*, for instance, is so fascinating that it is perfectly adapted to stimulating the audience's interest. The teacher can also use history of sciences, which places knowledge in its temporal and social context, thus giving the *discovery* its proper dimension. A good way to start can also be to use current events and reading a news article or screening a TV show.
As a rule, the pupil has to feel concerned with the subject tackled, or else he cannot be inspired. And inspiration/motivation is the key to the learning process. This is why the brainstorming is so relevant. It is intended to rivet the learners right from the beginning in the ensuing process of acquiring knowledge.

Confront himself/herself – be disrupted, puzzled, confronted to other realities
'*In order to favour learning, one has to worry reason and disrupt the habits of objective knowledge*', declared Bachelard (1938). Conceptions are indeed major parameters, since they are the only tools the pupil has to understand the world that surrounds him/her, so he/she holds tightly to them. He/she must be put in a situation that allows him/her to see the limits of his/her reasoning. Only then, he/she will feel the need to transform his/her conceptions for new and more operative ones.
To do so, situations of *confrontations* are more than favourable. This idea reaches its climax with the socio-cognitive conflict movement (Vygotsky, 1933; Gilly, 1989) which brings two people face to face in debates and make them defend their diverging opinions. These situations bring the pupils to argue, and defend their own ideas. The definition of levitation seen in text box 1 makes up an extremely rich phase of confrontation and development in common. Indeed, the debates are passionate, since it is quite tricky to find a scientific definition for a notion usually seen as describing a *paranormal* phenomenon.
Disruption can also rise from the clash of the pupil with the reality, through projects or experiments *he/she* realises. Or even with knowledge itself, through media, textbooks, meetings with scientists… On this account, surprising experiments such as counter-intuitive ones (Eastes & Pellaud, 2002) can be particularly effective in questioning and puzzling him/her: still related to the study of levitation, keeping a table tennis ball in the vertical flow of a hair dryer is a particularly interesting example of this kind of experiments.

Trust, dare to *let* go, be escorted
If disruption is an ideal tool to shake the cognitive system of the pupil (Giordan, 1987, 1996, 1998), it can also become an obstacle if the destabilisation is too strong or if the pupil feels *abandoned* in this moment of great emotion, even distress (Yanni-Plantevin, 1998), provoked by the transformation of conceptions. Therefore, the teacher's task is to develop a climate of trust, so that the pupil dares to *let go*: '*make them like you, let them feel free with you, and do not let them fear to show you their flaws*', would say Fénélon as early as 1809.
Self-confidence can only be reached through the establishment of a healthy relationship between teacher and learner, as well as among the class group. To achieve this, we have to take into account some important parameters. First of all, the pupil must have the possibility to express himself/herself without any risk of being judged. Then, he/she must have the right to make mistakes. A mistake does not necessarily mean failure, and understanding where it comes from is often a greater boost then succeeding first hand – generally due to pure luck!
Then again, the discussion phase, or brainstorming, seen in the study of levitation, allows the mediator to escort the audience steadily, while the conceptions surface. For instance, we can notice that for some, the objects lie on the floor because the air *pushes down* on them. This idea can be valued by the mediator who can ask the audience the origins of such an idea, probably linked to the fact that some already know a little about the notion of pressure. Coming back to the juggling show, the mediator can also ask the audience about *forces* at play on the balls during the different phases of their movements. And by doing so, he/she allows usual conceptions to emerge, which mainly appear when mentioning an upward force in the ascending phase of the balls. By imagining experiments or reasonings that invalidate these hypothesis, or even better, by letting the audience imagine them, he/she will stimulate both their self-confidence and their interest for the subject.
It is also worth noting that if the mistakes, or to a larger extent, ignorance, are seen as key elements in the learning process, it happens to be an extremely useful tool in the construction of the relationship between the learner and the teacher. Especially if the latter recognises his own limits (Fénélon, 1809; Bachelard, 1938) and accepts that he can also learn from the pupil.
There is, eventually, a third parameter: assessment. Instead of always giving lessons-based tests, chiefly focused on the memorizing of notions, it is important to work more towards training assessment, even self assessment, which could be very effective.

In such a view, the teacher is no longer the almighty one thanks to his knowledge (Houssaye, 1988). He becomes an *articulator* (Pestalozzi, 1802; Fénélon, 1809; Rogers, 1979), an *escort* (Rousseau, 1762; Cousinet, 1950), a *mediator* (Raynal & Rieunier, 1997; Rezeau, 2001) or even a *guide* (Montessori, 1958). The teacher no longer intervenes as *dealer* of knowledge, but as an *organizer* of learning conditions. He/she maintains the right balance between disruption and escort, as a surplus of anyone of these parameters could stop the training process.
Managing the time for learning is also a fundamental role of the teacher. Learning takes time. And this requirement has already been pointed out by Rousseau, when he exclaimed, in 1762: '*Dare I expose the greatest, the most important, the most useful rule of all education? It is not to gain time, it is to lose it*'.

Be able to imagine, dare to innovate
'*It is often said against any pedagogy founded on imaginary that imagination is not useful, that it is even damaging to the scientist training that man needs nowadays*'[4]. Yet, more than anything else, imagination helps us understand the real world and the scientific one. Thanks to it, the pupil ventures beyond the known into the unknown. It is imagination that can allow him/her to theorise and to step back enough to find far from obvious solutions to a given problem.
Thus, extremely original solutions can take shape in the pupils' mind. We can think of, for example, the mention of a phenomenon with no apparent link with the subject: the Archimedes' principle. Whether it works in the water or in the air, it becomes the opportunity for the pupils to test daring and imaginative hypotheses.

Be able to mobilise knowledges, and articulate them around organising concepts
The learner has to use a knowledge, for it to really become operational. The task of the teacher is to provide him/her with the situation where he/she will be able to invest it again. This reinvestment often allows the learner to build a web between existing knowledges and fields of study, but also to understand the interactions at play, mostly when this reinvestment is articulated around *organising* (Pellaud & Giordan, 2002), *interacting* (Haguenauer, 1996) or *structuring* concepts as Ausubel (1966) considers them when he speaks of *organizers*. This mobilisation, which goes beyond the simple idea of *transfer* (Meirieu, 1998; Meirieu & Tardif, 1998; Develay, 1998) implies the ability of recognising the similar in the different, of disconnecting from reality, of stepping back and to reach a kind of abstraction. A variety of pedagogic approaches allow the pupil to be put in situation of reinvestment. Letting the pupils use their specific skills in group work (Blaye, 1989), favouring connections and interdependencies out of works on transversal and interdisciplinary subjects, the way Comenius already recommended in the 17th Century, the teacher favours an independency of the mind. There are many other practical means to get the learner used to decontextualizing and recontextualizing a knowledge in different ways. The learner can put up a role-playing game, an exhibition, or even teach to others.
For instance, watching the experiment of a magnet falling into a copper tube, the pupil will be puzzled by the fact that the magnet is slowed down by the existence of a strong electromagnetic induction (even though the copper is not magnetic). The pupil will thus be encouraged to link the phenomenon to the mechanism of the electromagnetic speed reducers equipping trucks. And also to understand the energetic implications of the phenomenon, linking, for example, the energy taken from the fall of the magnet to the luminous energy dispersed by the bicycle light powered by a generator. If we consider higher education, the study of the links between levitation of the tennis table ball mentioned above and the sustentation of planes can also carry a great deal of potential.

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[4] JEAN, G. (1976) *Pour une pédagogie de l'imaginaire*, Collection "Orientations E/3", Casterman, p. 24

Design, reflect upon his/her own knowledge

Even though current schooling systems keep on *piling up* trivial and disparate knowledges, it is well known that there is more to learning than just acquiring knowledges. Still, they remain important, to develop both curiosity and a critical mind, for instance, but we have to be careful enough not to treat them as dogmas.

The required *behaviours* to build up this state of mind (critical mind, curiosity, self-confidence) cannot emerge without *knowledges* nor without thinking and stepping back, coming both from *knowing knowledge*. They also cannot surface without certain *skills*, like analytical approach, experimental systemics… These four types of knowledges are completely interdependent and can only develop when together.

When showing experiments both impressive and technologic, like the levitation of a magnet above a superconductor plunged in liquid nitrogen, or the generation of an array of spikes in a ferrofluid, the presented knowledges can only make sense if contextualised. One has to understand the possible use of these materials (EMS trains, bank notes impossible to counterfeit…). In the same line of reasoning, mentioning the technological implications related to the experiment, the economic aspects or even ethical issues linked to their coming into play can help to offer, on top of academic knowledge, a real reflection about science and its stakes.

Thus, it is the teacher's duty to offer situations that allow the pupil to build a web between knowledges, thanks to a variety of proper methods and tools. This brings us naturally to the last parameter mentioned in this didactic environment: think assistant.

Work up think assistant

Think assistants, as Giordan (1998) defines them consists of everything the teacher has to offer, in relation to information medium or methods, to put learning within reach. Inside the sequence described above, as in any mediation situation, be it a lecture or an experimental approach, a group work, a museum trip, a specialist's intervention, researching information (internet, works, media), a project, defining objectives, putting up of a show, using games, simulations or models, designing concept maps, metaphors, stories, everything can be used to give the learner the best chances to reach knowledges and to transform his/her conceptions.

Conclusion

Thus the learners, by putting sense into it, by reinforcing it and by connecting all its components, build their knowledge little by little. The most important in such an approach is the independence that the learner reaches in relation to his training. This independence will help him develop both a critical mind and a creative imagination, capable of outmatching the recommended models – recommended not only by the teacher but by the society as a whole.

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