From constructivisme to allosteric learning model

Paper presented at the UNESCO Conference on Science Education : 2000 and 1996

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During the last ten years, researches on science education have shown that the level of students is rising. New curriculums present a lot of subjects in different new fields : biochemistry, immunology, cell biology, electronic, computers... The knowledge learnt however, is proved to be of little use afterwards. It is forgotten in the space of a few years and may be even of... a few weeks! Their transfer into an out of school context is laborious. They have no integrating role, neither for treating the flow of information from the media, neither for understanding their own body or their environment.

Contrary to what is commonly believed, it is not because a teacher has covered his curriculum and taught his class conscientiously that he has necessarily conveyed knowledge. Fundamental concepts are never acquired through direct transmission from a teacher to a learner. The traditional methods for transmitting knowledge, the various active pedagogical innovations fall short of expectations. The didactic ration, i.e. the amount of knowledge acquired as compared to the time spent, is very poor, sometimes inexistent.

For example, we have published a study on digestion. The question was : "what happens to the food beyond the mouth"? After a first lesson, we can categorise three different conceptions built on remarks of five-year-old pupils:

- "food enters the mouth and goes down into the stomach" (1),

- "food enters the mouth then goes out" (2),

- "we have two tubes ..., one for solid food, another for liquid food... to the bladder" (3).

The problem is that you find the same ideas after a second lesson, at the end of elementary school, the same at the beginning and the end of secondary school... through to the university. These conceptions are even found among teachers in training.

Conceptions of teachers in training

Some reasoning "errors" or "erroneous" notions appear again and again with baffling regularity among pupils, and this even after numerous learning sequences. Another example, at the university, students that known all on electronic reactions about the photosynthesis but they continue to tell : "plants take food only in the soil" or the leaves contains a sort of stomach".

So today, we have to produce new models on learning and teaching sciences. For that purpose, we have two questions to keep in mind : How can the appropriation of this knowledge by learners be optimal? But also, what knowledge must be handed down for the years 2000 ?

The appropriation of this knowledge

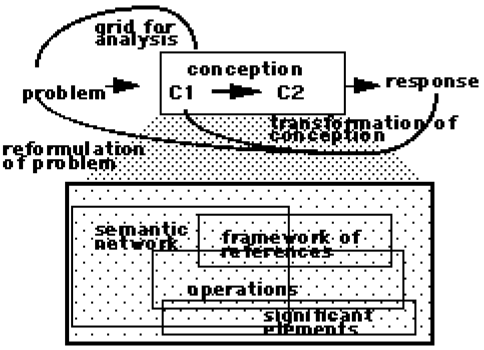
On the first point, the first hypothesis were formulated - fifteen years ago (Giordan 1978)- was that the learner's system does not work like a passive recording system. It has a specific mode of explanation - called *conceptions* in our didactic jargon - which determinates the way it decodes information and constructs knowledge. It's the only instrument (panel), he has at disposal.

Learning depends on these prior thinking notions. It is also through them that the learner interprets information spread by the teacher or the media. If teaching does not consider this fact, if teaching does not work on the learners conceptions, the sitting notions hold their own and the conveyed knowledge is evaded, transformed or stay isolated from the familiar knowledge. It is not because a teacher says something, presents different facts that the learner learns. The direct transmission knowledge is rarely the best way for learning.

The places of the conception

Now this hypothesis is largely corroborate. It appears that the learning of any piece of knowledge depends on the pupils conceptions, and if the teacher ignores them, "sitting" notions work as an obstacle (a sort of snag). This hypothesis has conducted our laboratory to produced a lot of researches in this field. Mainly we have categorised different conception on different subjects, we have explained the different obstacles.

We have also constructed different tools to define what is a conception and how it's work. In a first approximation, we can say that the conception is not only an image, an simple idea, a simple production of the reality. It is a thinking process, a answer to a question. The conception present different levels of organisation.



Conception organisation

The uses of the conceptions

But today we must go further. The knowledge of the pupils conceptions is useful, but not sufficient. The new research question is : how to use learner conception ? With that question in mind, we have listed different uses of conceptions in the classroom, we find a lot of different approaches. In 90% of situations they clearly suggest either to ignore conceptions or to avoid them. This first point of view is based on the ideas popularised by CONDILLAC. It is thought that "saying" or "showing" is sufficient for the pupil to adopt and register knowledge in the same way as "soft wax can register any imprint".

The second position is derived from the behaviouristic or neo-behaviouristic theories : "providing the right sequence of adapted activities is enough to bring about learning". It is the third position which concerns us in this kind of research, the one which advocates "being aware of conceptions". In fact, when one run through the literature in this field, this position can be, in its turn, broken down into several hypotheses (see chart below).

When discussing the different positions on conceptions, these researches lead us to suggest a set of micro-model known as*allosteric learning models*. It offers a number of propositions to go beyond the constructivist model as well as an environment for learning.

Allosteric learning models

Learning includes a number of many, multifunctional and pluricontextulized activities. Learning mobilises several levels of mental organisation that, at first glance, seem disparate as well as a considerable number of regulation loops (feed-back). Trying to explain everything with one single theory is attempting the impossible.
In order to go beyond the constructiviste model, a number of micromodels have been created and gathered under the comprehensive term : allosteric learning model. They describe what is going on in the learner's head as well as the general conditions that make learning easier. They validate, in particular, the efficiency of a didactical environment interacting with the learning strategies of the learner.
In the act of learning, the regulations that a teacher may introduce, his capacity for involving the student, for providing bearings or helping on with conceptualisation are primordial.

A student learn simultaneously "thanks to" as says (GAGNE), "starting from" (AUSUBEL), "with" (PIAGET), the functional knowledge inside his mind, but at the same time, he must learn" against" it (BACHELARD). Learning is not a simple "association mechanism", an "cognitive bridge" operation or a simple "assimilation-accomodation" mechanism.

Learning is a highly active process which works in a conflicting way and in an integrative mode between what the learner has in his mind and what he can find and understand through his conceptions on his environment. When a learner elaborates a new model, all his mental model must be reelaborated in an interaction between the conception and the external information. And this, is not obvious. Student changes ideas with a lot of difficulties. This process makes a lot of perturbations. All change also produce some anguish.

Mainly his questioning network must be completely reformulated, his framework of references, largely reorganised. And when a pupil changes his conception, it's not because he is convinced that it doesn't work, it's because he has elaborated another one which is more efficient to answer to the question he is confronted with. And this need conflict and interference periods and the elaboration of knowledge goes on with approximation, concernation, confrontation, decontextualisation, interconnexion, rupture, alternate, emergence and mobilisation periods.

A didactical environment

This change of ideas on learning have some consequences on teaching. The learner is the one who elaborates, integrates... learns in short, and all this through his own thinking system. Nobody can produce that instead of him. He is the one who must, somehow, find himself in a situation calling for a change of conceptions.

Fortunately for... the teacher, the learners cannot do this always alone. Most of the time they need a didactic environment to cause interferences with their sitting conceptions. And this is the main functions of the teacher : he has to propose or to suggest an heuristic environment that may interfere with the learner conceptions.

This environment depends on the learner, on the knowledge and on the learning context, it present individual differences, but significant parameters which must concur to a didactic environment may be listed.

First, it's necessary to induce a series of conceptual imbalances. The main problem is to start an elaborating activity in the learner. To achieve this, the teacher must motivate him in relation with the question to be studied or, at least, to make him enter into it.

A number of authentic confrontations is indispensable :

- pupil-reality with observation and experiment;

- pupil-pupil by working group;

- pupil-information with documentation work or inquiry;

- pupil-teacher.

All that authentic confrontations must convince the learner that his conceptions are irrelevant to the problem. The conception change requires a number of arguments - and not a single one - hastily presented. The different confrontations must lead him to gather new information to enrich his experience about the question. They must lead him to adopt a detached attitude about his self-evident notions and, most often, to reformulate the problem.

Secondly, it is important for the learner to have access to some formalism, as an aid to thinking. This formalism which may assume various forms (symbolism, schematisation, modelisation) must be easy to handle in order to unable him to organise new data or to use it as an anchorage to produce a new structuration of knowledge.

On this point, a number of investigations are under way and it seems that the model used in science research isn't often the best one in the classroom. Different procedures may be used successfully at different times. At an early stage, it appears that, it is more profitable for the teacher to provide the outline of a model. Yet he must take a number of precautions: it is useful that this pre-model should be easy to read and to understand, and adapted to the way the pupil perceives the problem. In the same time, it is advisable that the learner should have had a previous opportunity to produce some models and to operate them.

Lastly, it is important to allow the learner to operate knowledge on knowledge, mainly to think upon conceptual practices, to realise their scope and value or, again, to become aware of the logic underlying the selected approaches. Many reported difficulties point out that, sometimes, the obstacle to learning is not directly linked to the thing to be learnt but, rather indirectly, to the conception or the intuitive epistemology the learner has about the experimental approach or about the process of producing knowledge.

From all these points put forward, it appears that the teacher's role is of prime importance and irreplaceable: the mass of information, its interactions, the gradualness or its appearance cannot be planned beforehand. Yet, this role is subordinate: the teacher is only the organiser of learning conditions. But to go forward in this way, an another question has to be discuss: in which direction science education may go. In other words, what can be the basic scientific concepts and skills that all children should known ? Shouldn't "knowledge", in view of the years 2000, be considered as an answer to questions and to problem-solving situations. This would mean manipulating or producing models, making simulations, combining and integrating concepts belonging to different disciplines.

So our outline of basic biology objectives encompasses three groups of priorities that together must be taken into account for basic biology teaching:

- prerequisities for a scientific attitude,

- mastering the process of investigation,

- organisation of knowledge around structural basic concepts.

A piece of knowledge on knowledge becomes an important parameter too. This point has been developed in another paper.