Degree IN TEACHER OF PRIMARY EDUCATION.
Subject: Didactics of Experimental Sciences
Course: 17-18

Chapter 5.- Learning Science

5.1. Important Aspect of Learning of Science

The predominant influence of behavioral psychology in education in recent years has led to conceptualize the student's mind as an empty closet on which the teacher could introduce knowledge subjecting the student to a whole range of stimuli and rewards. On the contrary, it is being recognized that learning occurs as a result of an interaction between what the teacher teaches and the pre-existing ideas or concepts in the student's mind. From this point of view, learning does not simply involve the absorption of new information, but involves the partial or total modification of the cognitive structure of the student. Previous and recent research (Sebastia, 1984, Viennot, 1979, Mora and Herrera, 2009) have shown the existence, in students of any level, of a set of beliefs and expectations, which constitute a kind of "intuitive physics" that it provides a satisfactory understanding of the world.

In the research developed in recent years, on didactics of experimental sciences, an analysis on what are the ideas used by students for the interpretation of various phenomena before receiving teaching in which they learn the scientific explanation. These ideas prior to teaching have a great relationship with the conceptual errors committed by the students, in any area of science, although they have received formal instruction on the subject throughout their academic career.

Nowadays, there is a general agreement about the concept of knowledge as it must not be considered as a copy of the reality, in which the student plays a totally passive role, but on the contrary, the individual is recognized as the role of " generator "of his/her knowledge (Osborne and Wittrock, 1983), according to constructivist theory (Osborne and Freyberg, 1985), and accepting Piaget's ideas concerning the importance of the action of the subject in the construction of that knowledge. The main characteristics of the constructivist vision (Driver, 1986, Driver, 1988) are:

What is in the brain of the learner is important

The learning outcomes depend not only on the learning situation and the experiences we provide to the students, but also on their previous knowledge, their conceptions and their motivations.

Finding meaning involves establishing relationships

The knowledge that is conserved over time in the memory are not isolated facts, but refer to those very well structured and interrelated in multiple ways, so it is necessary to establish an internal coherence of the matter, an existence of relationships and connections between the different parts of the subject.

Whoever learns actively constructs meanings

The construction of the meaning is used to find the meaning of the experiences without major conceptual changes of the individual being necessary, in addition it can also imply a process during which existing ideas must be used in a new way. It is this

restructuring process that would be necessary for students to produce as a consequence of new activities proposed in teaching.

Students are responsible for their own learning

This degree of responsibility given to the students must be directed to get them to put their attention on certain tasks and making use of their own knowledge to achieve the self-construction of meanings in learning. The teacher must have his influence but more focused on a motivating role, and properly structuring the material to be learned.

In principle, in this chapter, we are going to analyse what it lays behind answers as:

"To move a body you have to push it with a force greater than its weight..."

"A battery is worn out when the charges run out..."

Sometimes, the reasons of these responses are coming from expressions given by teachers and show their low implication in the learning-teaching process. These expressions can be:

"Students do not study"

"It does not happen to my students, there are "other teachers" who cannot explain."

"There is very little time to teach Science"

5.2. Conceptual Errors, student´s previous ideas, difficulties on learning process

For a long time, teaching of theoretical concepts worried to the science teachers less than other aspects such as the resolution of problems or the realization of laboratory practices. Analogously, it also happened among those who were engaged to educational research works about the teaching and learning of sciences This initial situation was due, in part, that the failures in the resolution of problems (with its high index of failures) or limitations of the laboratory practices (barely present), were more worrying sometimes compared to the difficulties in understanding of the concepts, since most of the students got better results in the theoretical part of exams. However, it could be thought that the apparent facility to respond to the "theoretical" questions that were usually proposed was rather the result of a simple memory repetition. In fact, could one speak of real comprehension of concepts when those students were not able to apply them adequately to solve simple problems?

The publication of some rigorous studies, such as the Viennot thesis (1979), attracted attention on the problem of conceptual learning, which questioned the effectiveness of teaching where the results seemed more positive; the students not only finished their

studies without knowing how to solve problems, and without an adequate appropriation of what scientific work is, but the immense majority of them had not even managed to understand the meaning of the most basic scientific concepts. Particularly relevant was the fact that the mistakes they made in answering questions such as the one mentioned above were not mere forgetfulness or momentary mistakes, but expressed as safe and persistent ideas, similarly affecting students from different countries and levels and even to a significant percentage of teachers.

To this type of "mistakes", contradictory to current scientific knowledge, widely spread, which are usually given quickly and safely (hardly leave blank answers), which are repeated insistently and that are related to certain interpretations of various scientific concepts, they are often called **conceptual errors** and the ideas that lead to committing previous ideas (because they really respond to the existence of ideas very different from the scientific ideas that we want to teach). These alternative ideas are those that in the previous questions lead to answer mostly in a coherent way with them and constitute a serious obstacle to the learning of sciences. In addition, some authors believe that the wrong answers of students is produced by lack of attention to the proposed question or because they answer without sufficient information, taken from the urgent need to answer all the questions asked by the teacher (Mc Clelland, 1984, Nussbaum, 1981).

These errors have some common characteristics, such as the following:

❖ **They are repeated throughout the different levels of education despite the teaching of scientific knowledge that contradicts them.**

❖ **They are associated with an interpretation of different concepts (force, gravity, photosynthesis...) different from the interpretation that scientists make.**

❖ **They are quick answers and without hesitation, convinced that they are well.**

❖ **They are given by students from different countries, including some professors**

Attempts to explain the abundance and persistence of these conceptual errors in numerous domains of science have basically aimed at two causes; on the one hand, it is believed that these errors are the previous ideas that students have prior to school learning and on the other hand, the attention has been directed towards the usual type of education, calling into question that the transmission of elaborated knowledge makes possible a meaningful reception of them, that is, make it possible for students to learn significantly the ideas that have been transmitted to them.

Next, we will focus in more detail on the **concept of previous ideas**, as well as their origin and cause.

Concept of previous ideas

As we have mentioned previously, they are the ones that have the students, normallly very different from the scientific ones that we want to teach them. These ideas are considered the origin of the conceptual errors and it has been observed a persistence of these intuitive ideas maintained by the students over the years before receiving formal education making more difficult to change them. But this difficulty is not the same in all the subjects, being greater the persistence in those are related to facts and phenomena that the students observe with frequency. Also, this constancy in the ideas of the students, often not compatible with the scientific aspects and their effect on the learning of the concepts has stimulated studies and investigations to understand how these ideas originate, how they influence the teaching-learning process and how affect learning outcomes.

Hashwesh (1986) raised the reason for this resistance to the change of these intuitive ideas by students. He stated that logically the answer to this question must be related to both the nature and the type of teaching that "in theory" should change them. Hashwed pointed to a number of reasons. Among the factors of psychological type, it indicates the tendency of the students to consider only the tests that confirm their hypotheses. Sometimes, students have such confidence in their hypotheses that they do not even bother to verify it. We could say that more than hypothesis-conjecture, in which the possibility exists that they are not true, they are hypothesis-postulated in the sense that they are true in themselves. However, these psychological factors are beneficial for the emotional stability of students, because they are the basis of self-confidence and facilitate the automatic decision making that we have to face continuously. These previous ideas have different features, which can be summarized as:

❖ **They are not scientifically correct.**

❖ **They are domain specific and frequently depend on the task used to identify them.**

❖ **Most of these ideas are not easy to identify because they are part of the subject's implicit knowledge.**

❖ **Many of them are guided by the student's perception and experience in their daily lives.**

❖ **They correspond to personal constructions.**

❖ **They do not all have the same level of specificity and generality, therefore the difficulties they generate are not of equal importance.**

❖ **Often they are very resistant ideas and, consequently, difficult to modify.**

❖ **The degree of coherence and solidity is variable, it may be diffuse representations more or less isolated to form a more complete mental model even with some capacity for prediction.**

Starting from these features, we should consider the causes and/or origin of these ideas. In this way, we can establish several aspects related to this origin:

Influence of everyday life experience

The most persistent alternative ideas, the most difficult to change, are those that are most related to the evidence of common sense.

The gases hardly weigh ***A balloon falls more slowly than a stone***

Daily language of meaning different from the scientific

There are terms that have a different meaning in everyday language and in the scientific one. Thus, work is associated with effort and fatigue in everyday language, while having another meaning in physics.

Close the window that enters the cold (or the heat goes out) ***Turns off the lamp that loads a lot of current***

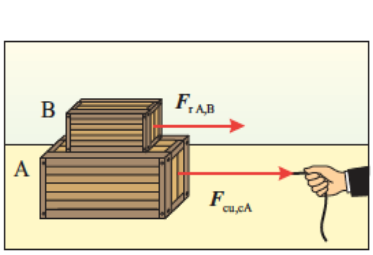
Existence of errors in textbooks

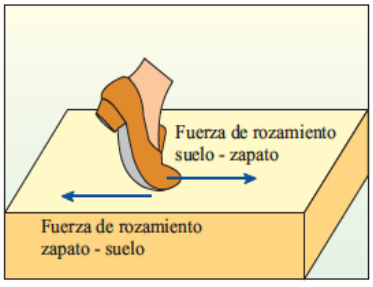
Sometimes, textbooks present different errors which can produce students misconceptions due to the fact that the information shown is erroneus.

The force of friction is always contrary to the movement or opposes it. ***The moles are passed to grams using the molecular mass.***

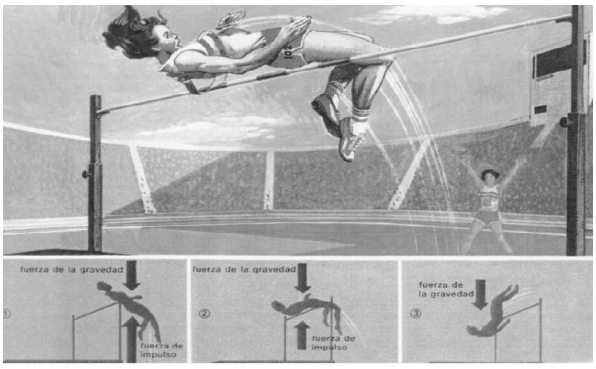
Some examples can be observed on the next figures:

The friction force is always contrary to the movement or opposes it





The friction force is contrary to the relative movement between the two contacting surfaces.



Explanation of a high jump
When the feet are not in contact with the ground there is no force drawn up.
In all three situations there is only the attraction of the earth on the jumper, which in drawing is called the force of gravity.

Not taking these ideas into account in teaching planning

Many teachers do not consider the previous student´s conceptions in order to plan their teaching planning. This can be due to the fact their own considerations about the way to teach and/or they still believe that the students should be a inactive figure during the learning-teaching progress.

5.3. The Conceptual Change Model

Although Piaget (1974) developed one such theory there appears to be a need for work which focuses "more on the actual content of the pupil's ideas and less on the supposed underlying logical structures" (Driver, 1978). However, there has been no a well-articulated theory explaining or describing the substantive dimensions of the process by which people's central organizing concepts change from one set of concepts to another set, incompatible with the first one. So, a major source of hypotheses concerning this issue is contemporary philosophy of science, since a central question of recent philosophy of science is how concepts change under the impact of new ideas or new information. In principle, this more or less recent trend is the base of **the Conceptual Change Model.**

In that sense, **learning is considered as a rational activity**. That is, learning is fundamentally coming to understand and accept ideas because they are seen as intelligible and rational. Learning is thus kind of inquiry, because the students must make judgements on the basis of available evidence. The claim that learning is a rational activity is meant to focus attention on what is learning, not what learning depending on.

Learning is concerned with ideas, their structure, and the evidence for them, as it is not simply the acquisition of a set of correct responses, a verbal repertoire or a set of behaviours.

In summary, as well as one inquiry, **learning is best viewed as a process of conceptual change.**

The epistemological base

Contemporary views in philosophy of science suggest that there are two distinguishable phases of conceptual change in science:

1º Phase: Scientific work uses the background of **an organized research** (define problems, indicate strategies and results). Thomas Kuhn called them "**paradigms**", and paradigm-dominated research "**normal science**".

2º Phase: All research stages require **modification**. Scientist is faced with a **challenge to his basic assumptions** and must **acquire new concepts** and a new way of seeing the world. Kuhn called it as "**scientific revolution**".

In that sense, we can consider analogous patterns of conceptual change in learning:

Assimilation (similar to the "normal science" of Thomas Kuhn)**: Students use existing concepts to deal with new phenomena**

Accommodation (similar to the "scientific revolution" of Thomas Kuhn)**: Students' concepts are inadequate to understand new phenomena and must be replaced or reorganized.**

But, two immediate questions could why we need this conceptual change?, and how is going to be produced? The answers can be expressed as:

❖ **There must be dissatisfaction with existing conceptions.**
Before an accommodation will occur, it is reasonable to suppose than an individual must habe collected a sotre of unsolved puzzles or anomalies and los faith in the capacity of his current concepts to solve these problems.

❖ **A new conception must be intelligible.**
Knowing what it means. The importance of analogies and metaphors in lending initial meaning and intelligibility to new concepts.

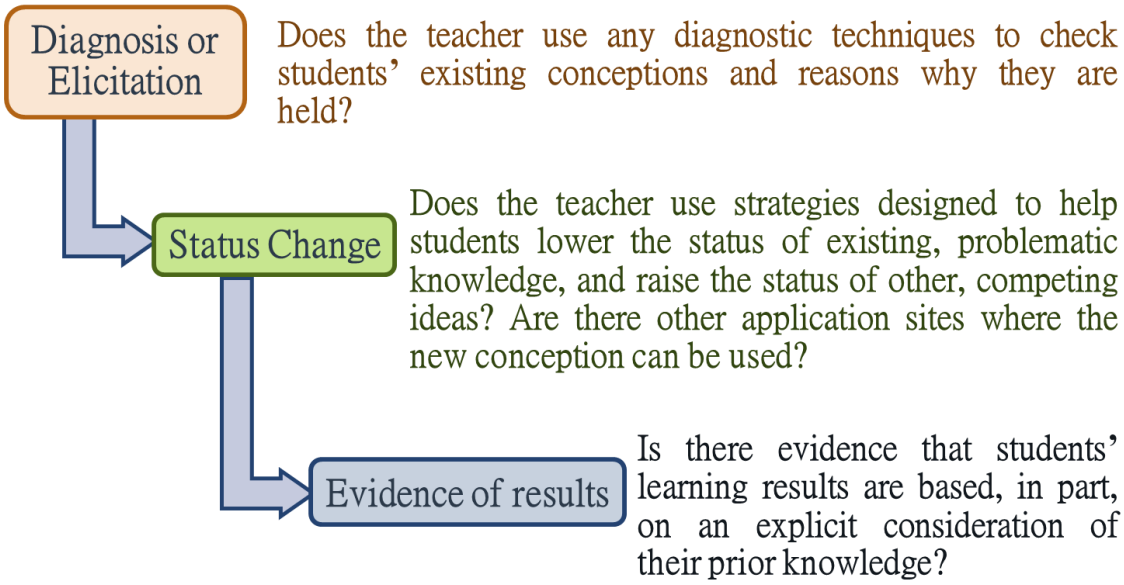
❖ **A new conception must appear initially plausible.**
Believing it to be true

❖ **A new concept should suggest the possibility of a fruitful research program.**
Finding it useful

❖ **Learning a new conception means that its status rises, i.e., the learner understands it, accepts it, sees that it is useful.**
If the new conception conflicts with an existing conception, i.e., one that already has high status for the learner, it cannot be accepted until the status of the existing conception is lowered. This only happens if the learner holding the conception has reason to be dissatisfied with it.

In principle, the purpose of conceptual change teaching of science is not tu force students to surrender their alternative concepts to the teacher's or scientist's conceptions but, rather, to help students both form the habit of challenging one idea with another, and develop appropriate strategies for having alternative conceptions compete with one another for acceptance.

We can considered that there are different stages in Conceptual Change Teaching, where a series of questions must be raised that lead to reflection over the whole of the teaching-learning process:



In addition, we can considered that there are particular features present during different stages in Conceptual Change Teaching where, again, following a series of question, we can improve our practice on the classroom:

- **Metacognition**
  Are students encouraged or able to "step back" from one or more ideas held by themselves or others in order to think about them and express an opinion about them?

- **Classroom climate**
  Is there an attitude of respect by both teacher and students for the ideas of others, even when they are contradictory?

- **Role of Teacher**
  Is the teacher able to provide opportunities for students to express themselves without fear of ridicule, and to ensure that he or she is not the sole arbiter of what counts as an acceptable idea in the classroom?

- **Role of Learner**
  Are students willing to take responsibility for their own learning, to acknowledge others' ideas, and to change their views when another seems more viable to them? Can students monitor their own learning?

To finish this chapter, we need to consider some aspects related to the role of teacher and what he/she should carry out previous and/or during the teaching-learning process. In that sense, all teachers should:

❖ **Know the phenomena, the methods, and the concepts, principles, and theories that constitute the science they are teaching**.

❖ **Know what conceptions their students hold about the units to be taught, and the extent to which they are scientifically acceptable**.

❖ **Be aware of the role played by students' existing knowledge in understanding new material.**

❖ **Be convinced of the need to use conceptual change teaching strategies particularly when students' existing conceptions conflict with those being taught**.

❖ **Be able to plan and perform teaching actions than give effect to these strategies**.

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