

Degree IN TEACHER OF PRIMARY EDUCATION.
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Chapter 5. Learning Science

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5.1. Important aspects of Learning of Science

In recent years, the influence of behavioural psychology on education is an accepted fact, which has led to the understanding of the student's mind as an empty closet in which the teacher introduces knowledge through a range of stimuli and rewards. However, we can also highlight the recognition 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 merely 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 an adequate 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 before 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 general agreement that the concept of knowledge is not like a copy of reality with a passive role for the student. On the contrary, the individual is recognised as the "generator" of his knowledge (Osborne and Wittrock, 1983), according to constructivist theory (Osborne and Freyberg, 1985), and accepts Piaget's ideas about the importance of the subject's action 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 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: Meaning construction is used to find the meaning of experiences without the need for significant conceptual changes of the individual. Also, it may involve a process where there is a new use of existing ideas. This restructuring process would need to take place in the students because of the new activities proposed in teaching.

Students are responsible for their learning: This degree of responsibility given to the students must be directed to get them to put their attention on specific tasks and making use of their knowledge to achieve the self-construction of meanings in learning.

The teacher must have influence with a motivating role and adequately structuring the learning material. In principle, we are going to analyse what it lays behind answers as:

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

“A battery is worn out when the charges run out...”

Sometimes, the reasons for these responses are coming from expressions given by teachers and show their minimal 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 the learning process

For a long time, many teachers were less concerned with teaching theoretical concepts than with other aspects such as problem-solving or laboratory practices which also happened among those engaged in educational research on science teaching and learning. Initially, this situation was because most of the students obtained better results in the theoretical part of the exams than in the practical part (problem-solving or laboratory practices). However, the apparent facility to respond to the "theoretical" questions was instead 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 studies, such as the Viennot thesis (1979), focused attention to the problem of conceptual learning, which questioned the effectiveness of teaching where the results seemed most positive; since, in most cases, students finished their studies without knowing how to solve problems, which is scientific work, and without understanding the meaning of the most fundamental scientific concepts. Particularly relevant was the fact that the mistakes 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. These kinds of "errors" are called **conceptual errors**, and the ideas

that lead to them are called **previous ideas** (because they respond to the existence of ideas that are 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 severe obstacle to the learning of sciences. Also, some authors believe that possible reasons of the wrong answers of students could be the lack of attention to the proposed question or because they answer without sufficient information, taken from the urgent need to answer all the questions (Mc Clelland, 1984, Nussbaum, 1981).

These errors have some common characteristics, such as:

- ❖ There is a repetition of these ideas throughout the different levels of education, although the teaching of scientific knowledge 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.
- ❖ Students from different countries give the same answers, including some professors.

Attempts to explain the abundance and persistence of these conceptual errors have been directed at two causes. On the one hand, the focus is on the previous ideas that students have before school learning and, on the other, it is on the usual type of education, questioning that the transmission of knowledge gives rise to a significant reception, that is, that students learn significantly the ideas transmitted. 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, usually 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 persistence of these intuitive ideas maintained by the students over the years before receiving a formal education, making it more difficult to change them. However, this difficulty is not the same in all the subjects, being higher 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 to 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. Hashwesh pointed to several 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:

- ❖ 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.
- ❖ The student's perception and experience in their daily lives guide many of them.
- ❖ 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 complete mental model even with some capacity for prediction.

Starting from these features, we should consider the causes and 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

Some terms have a different meaning in everyday language and 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

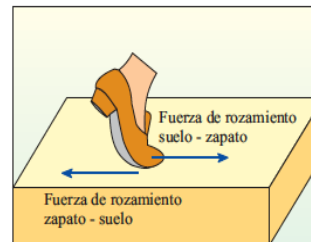
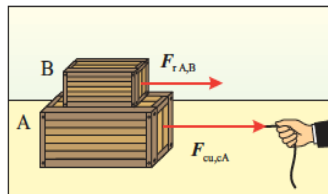
Sometimes, textbooks present different errors which can produce students' misconceptions because the information shown is erroneous.

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

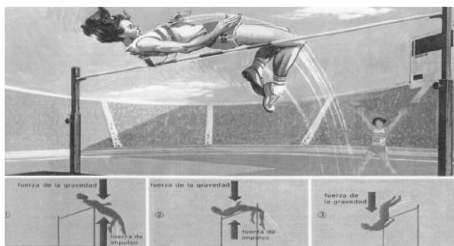
The moles are passed to grams using the molecular mass.

Next figures show some examples:

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. It can be due to the fact their considerations about the way to teach, and they still believe that the students should be an inactive figure during the learning-teaching progress.

5.3. The Conceptual Change Model

Although Piaget (1974) developed a theory of learning, in recent years, it seems that work is needed that is "more focused on the actual content of the student's ideas and less on the supposed underlying logical structures" (Driver, 1978). However, there has not been a well-articulated theory that explains how concepts change under the impact of new ideas or new information. It is the basis of the **Conceptual Change Model**. In that sense, learning is

fundamentally about understanding and accepting ideas through rational activity. Therefore, learning is an investigation where students must make judgments based on evidence. This statement aims to focus attention on learning and not on what depends. **Learning is concerned with ideas, their structure, and the evidence**, as it is not merely the acquisition of a set of correct responses, a verbal repertoire or a set of behaviours.

The epistemological base

Contemporary views in philosophy of science suggest two distinct phases of conceptual change in science:

1° Phase: Scientific work uses the background of **systematic research** (define problems, indicate strategies and results). Thomas Kuhn called them “**paradigms**”, and paradigm-dominated research “**normal science**”.

2° Phase: All research stages require **modification**. The scientist is faced with a **challenge to his/her basic assumptions** and must **acquire new concepts** and a new way of seeing the world. Kuhn called it a “**scientific revolution**”.

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

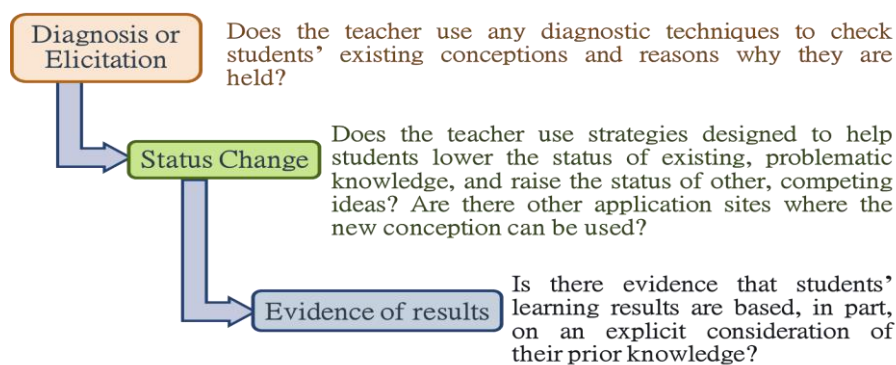
- ❖ **Assimilation** (similar to the “normal science” of Thomas Kuhn): Students use existing concepts to deal with new phenomena.
- ❖ **Accommodation** (similar to the “scientific revolution” of Thomas Kuhn): Students’ concepts are inadequate to understand new phenomena, and they have to replace or reorganise.

However, we can raise two questions: why do we need this conceptual change? Moreover, how is it going to happen? We can answer these questions as:

- ❖ **There must be dissatisfaction with existing conceptions:** Before accommodation occurs, an individual must have collected unsolved puzzles and think that is not able to solve these problems with the current concepts.
- ❖ **A new conception must be intelligible:** To know what it means the importance of analogies and metaphors in lending original 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 there is a conflict between conceptions, the learning happens if the learner is dissatisfied with the old one.

In principle, the purpose of conceptual change is not to force students to surrender their alternative concepts to the teacher's or scientist's conceptions but, instead, 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 consider that there are different stages in Conceptual Change Teaching, where we can raise a series of questions leading to reflection over the whole of the teaching-learning process:



Also, we can consider 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 in 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 learning, to acknowledge others' ideas, and to change their views when another seems more viable to them? Can students monitor their learning?

To finish, we need to consider some aspects related to the role of the teacher and what he/she should carry out previously and 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 didactic units 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 others.
- ❖ Be able to plan and perform teaching actions that give effect to these strategies.

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