Degree IN TEACHER OF PRIMARY EDUCATION.
Subject: Didactics of Experimental Sciences
Course: 2020-21

Chapter 5. Learning Science

5.1. Important aspects of Learning of Science

In recent years, we understand the student´s mind as an empty closet where the teacher introduces knowledge through a series of stimuli and rewards. However, we can recognise that learning occurs as a result of an interaction between what the teacher teaches and the pre-existing ideas or concepts in the students´ 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. Some researches (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 science" to understand the world properly.

In fact, in recent years, researchers have been collecting and analysing what those ideas used by students to interpret the world before they received the scientific explanation. These pre-teaching ideas are related to conceptual errors made by students. Nowadays, we consider the students as a “generator” of knowledge. This trend follows the constructivist theory and Piaget´s ideas). 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:*** Teachers should direct this degree of responsibility given to the students 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 teacher´s expressions and show their minimal implication in the teaching-learning 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

In recent times, many teachers as well as researchers in science education have seen how apparent good results in theoretical questions were due to simple rote repetition, and not to a complete understanding of certain scientific concepts, since students were not able to apply them to problem-solving or laboratory practices. For this reason, studies such as Viennot´s thesis (1979) focused on the problem of conceptual learning, which questioned the effectiveness of teaching where results seemed to be most positive; since many students ended their studies without knowing how to solve problems, what scientific work is, and without understanding the meaning of the most fundamental scientific concepts. These errors were not mere forgetfulness or momentary mistakes but were expressed as confident and persistent ideas, affecting equally students from different countries and levels and even a significant percentage of teachers. These kinds of "errors" are called **conceptual errors**. 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 focus on two causes. On the one hand, the focus is on the ideas that students have before school learning, namely **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 a severe obstacle to learning science the focus is on the previous ideas

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 the origin of the conceptual errors, and usually, there is a persistence of these intuitive ideas over the years before the students receive 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 relates to facts and phenomena where 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) stated that the resistance to change these previous ideas of students should be directly related to the nature or type of teaching that should change it, and pointed out several psychological reasons. Mainly, students tend to consider only the evidence that confirms their hypotheses, without the need to verify them. However, these psychological factors are beneficial for their emotional stability because they are the basis for self-confidence and facilitate 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.

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

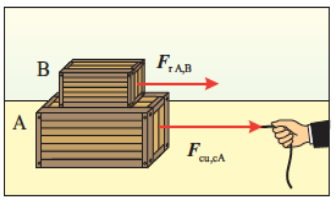
Sometimes, textbooks present different errors which can produce students misconceptions because the information shown is erroneous.

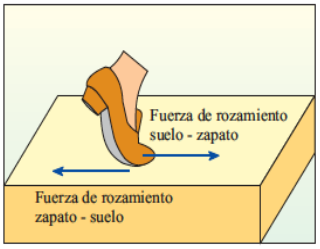
The force of friction is always contrary to the movement or opposes it.

The moles are passed to grams using the molecular mass.

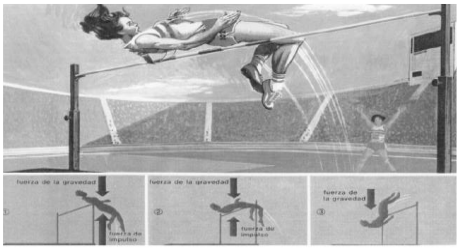
Next figures show some examples:

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.cIn 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 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 teaching-learning 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:

1º 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**".

2º Phase: All research stages require **modification**. The scientist is faced with a **challenge to his/her 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.

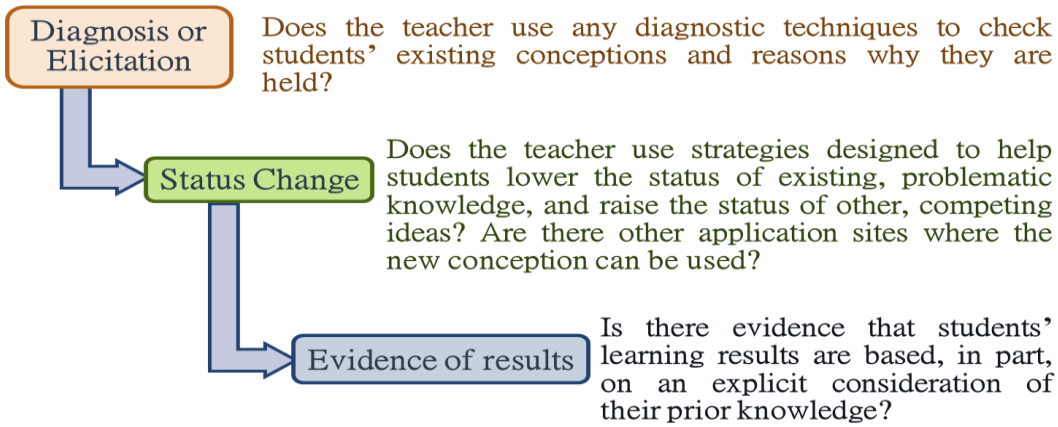
❖ **A new conception must be intelligible:** To know what it means the importance of analogies and metaphors in lending original meaning and intelligibility to new concepts.

❖ **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 than give effect to these strategies.

5.4. References

Driver, R, Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. Stud. Sci. Ed. 5, 61-84.

Driver, R. (1986). Psicología cognoscitiva y esquemas conceptuales de los alumnos, Enseñanza de las Ciencias, 4, 3-15.

Driver, R. (1988). Un enfoque constructivista para el desarrollo del currículo en ciencias, Enseñanza de las Ciencias, 6, 109-120.

Hashwesh, M. Z. (1986). Towards an explanation of conceptual change, European Journal of Science Education, 3, 383-396.

Mora, C., Herrera, D. (2009). Una revisión sobre ideas previas del concepto de fuerza. Lat. Am. J. Phys. Educ., 3, 72-86.

Piaget, J (1974). Understanding Casuality. W. W. Norton.

Sebastia, J. M. (1984). Fuerza y movimiento: La Interpretación de los Estudiantes, Enseñanza de las Ciencias, 2 (3), 161-169.

Viennot, L. (1979). Spontaneous reasoning in elementary dynamics, European Journal of Science Education, 1, 205-221.