The teaching of the concept of electric field: mountain or hill

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Abstract. In the paper we are presenting here we attempt to offer a plausible curricular solution to the learning difficulties met by common teaching when it comes to introducing the concept of electric field in introductory courses to Physics at High School level (ages 16 -18). The didactic approach used lies within a constructivistic frame, that is, one which considers that it is necessary to foster an ontological and epistemological change in order to act on the students’ alternative conceptions, or else the conceptual change cannot take place. First of all, we made out the materials needed for the implementation of the program in the classroom. In this, we have considered the different teaching and learning difficulties noticed by the literature. Once the program had been developed in the classroom we used qualitative and quantitative designs to evaluate the students’ learning.

Introduction. This research arises from the concern observed among High School teachers about the unsatisfactory results obtained when teaching electricity subjects, and particularly electrostatic ones.

Studies that tackle learning difficulties in electricity mainly focus on direct current circuits (Duit 1993) and do not link these difficulties with electrostatic concepts. However, the concept of difference of potential, for instance, that is one of the hardest to learn when studying basic electric circuits (Eylon & Ganiel 1990) keeps a direct relation with the concepts of electric field and potential taught in electrostatics. Research dealing with these difficulties related to the concept of field also shows that students have functional fixations grounded on the information received throughout instruction and that they tend to use the Coulombian conceptual profile to interpret electrostatic interactions. (Rainsson et al. 1994, Furió & Guisasola 1998).

When teachers in practice are asked to account for the general failure in the significant learning of the electric field concept, the main reason pointed out is that this concept is cognitively highly demanding, and thus it involves a large distance between the student’s thought and the high level of abstraction of the concept. Some other reasons frequently argued are: the poor knowledge of the mathematics tools demanded by the operative definition and its application (vectors, derivates, integrals) and the poor knowledge of the conceptual grounding in the area of Mechanics (force, work and energy).

As you can see these explanations impute failure to students’ weakness, which is one of the cue ideas among teachers’ “spontaneous thinking”. (Hewson & Hewson 1988). However it is surprising that they only refer to students’ deficiencies to account for the general failure in learning the concepts significantly. We could also look into the sort of teaching we are doing when most students are unable to achieve the significant learning of the electric field concept. We cannot forget that one of the variables that most influences the learning of concepts is the way they are taught.

When analysing common teaching most teachers agree on the importance of their
own deep knowledge of the subject they are to teach. This may seem obvious, something we needn't even mention, but it is more and more evident that a deep knowledge of the subject involves a series of aspects like being aware of the problems that led to the construction of scientific knowledge, their evolution and articulation into coherent bodies of knowledge, knowing the way in which scientists tackle problems, the interactions between Science/Technology/Society ..etc. (Duschl 1990).

If we were to consider the aspects pointed out, we should take into account that the definition of a concept results from a process of discussion and re-elaboration of some particular problem (Kuhn 1970). By not considering the introduction of a new concept as an hypothesis set in the frame of a process of research within a theoretical body, most teachers fail to take into account the ontological change that occurs in the way electrical interaction is conceived when passing from a Coulombian vision to one of electric field (Furió & Guisasola 1997). The lack of this ontological vision leads to considering the field theory as a form of accounting for electrical interactions in a more “abstract” way than the Newtonian one and therefore the need for its introduction is not emphasised during the teaching.

Furthermore, this teaching is mostly done through the oral transmission of knowledge and does not make students familiar with scientific methodology (for example, the qualitative treatment of problem situations, the posing of hypothesis or the design and carrying out of experiments so as to test the hypothesis posed ... ) which, considered together with what has been said in the paragraphs above, accounts for the great difficulties students have when learning the theory of electric field.

**Hypotheses and experimental design.** A didactic approach which agrees with the constructivistic perspective must support acting on the students’ alternative conceptions, give rise to the ontological change (forms of seeing the world) and the epistemological one (forms of reasoning) without which the conceptual change cannot take place and propose a teaching-learning strategy that improves the students’ attitude towards science and learning itself. In the paper we are presenting here we attempt to offer a plausible curricular solution to the learning difficulties met by common teaching when it comes to introducing the concept of electric field, a solution grounded on teaching strategies that can be considered within a constructivistic frame (Driver & Oldham 1986, Duschl & Gitomer, 1991), and more precisely, within the model known as learning by research (Gil y Carrascosa 1994, Guisasola 1995).

In accordance to the aforesaid, we have wondered to what extent it is possible to elaborate and develop, within the area of elementary electrostatics, an activity program which fosters a significant learning of the electric field concept. A condition prior to validating the program is to have the materials needed available for their application in the classroom. In order to make out these materials we have first pointed the characteristics that the new teaching characteristics must meet if they are to produce a lasting conceptual, epistemological and ontological change in students, and an improvement in their attitude towards the learning of electricity. Once the activity program was made, it was applied in two classes of 3rd year of BUP (ages 16-17) from different establishments.

The designs carried out in order to evaluate the learning achieved have been
multiple and convergent. The quantitative designs (surveys) were meant to analyse the differences between experimental and control students. Qualitative designs attempt to analyse the experimental students’ learning processes by means of the analysis of the data tape-recorded while the students interact in classroom situations. The conditions of application and the results obtained will be presented in the paper.

References.