Using Neuroscientific Evidence to Train Pre-service Physics Teachers on the Concepts of Heat and Cold

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Abstract. This communication describes an initial training course of didactics of physics. The main aim was to teach prospective teachers about the new understanding in neuroscience, which appears to explain the origin of alternative conceptions in thermodynamics. We assessed how prospective teachers applied this knowledge in their educational proposals. We found that the neuroscientific insights facilitated prospective teachers to incorporate children's misconceptions in their proposals. Additionally, alternative conceptions were mainly used as point of references to prepare their teaching sequences. However, these topics were not considered by preservice teachers as contents to be taught to children.

1 Introduction

Alternative conceptions in physics are tenacious and resistant to change [1]. Therefore, approaches are needed to effectively overcome them in class [2]. Research in neuroscience is changing our understanding of the nervous system and, consequently, the way in which we understand the mind. We now begin to understand how the senses filter, transduce and modify the information they receive. In this context, we taught prospective teachers about the new understanding in neuroscience, which appears to explain the origin of alternative conceptions in thermodynamics. We studied how they applied this new knowledge in their own teaching sequences.

2 Neuroscientific background

Transduction of the external and internal conditions is essentially mediated by proteins, called Transient Receptor Potential ion channels (TRPs). These structures are embedded in the neurons' membrane [3], and some of them are extremely sensitive to temperature changes such as the thermoTRPs. ThermoTRP can be classified into two groups: hot- and cold-sensitive, with a neutral range between 30ºC-36ºC. This means that hot and cold stimuli information are independently transduced and transmitted [4]. This separation is maintained in the spinal cord and in a few areas of the brain [5]. Therefore, when healthy humans touch an object the thermosensation machinery always classifies it into hot- or cold-objects [6]. This initial classification, which has a physiological origin, predisposes us to sense two distinct entities: heat and cold.

3 Research design

The aim was to investigate how prospective teachers applied the new neuroscientific understanding on the origin of alternative conceptions of heat and temperature in their teaching proposal. The study was carried out in the context of a constructivist-oriented training program about how to teach science in Secondary high school. It was a 45-hour course, from September

2016 to January 2017, with 36 prospective teachers which were organized into 6 teams. We followed a strategy called Reflection Orientation [7]. At the beginning of the course, they had to design an initial proposal for teaching 'Heat and Temperature' to secondary pupils. To assess their improvement in designing the proposal, students had to submit their education plan on 'Heat and Temperature' 3 more times. Due to space constraint, here we only show the results of the 4th proposal.

4 Results

The students' proposals were organized in the following sections: Introduction, Objectives, Contents, Activities and Evaluation.

In the *Introduction* and the *Activities* sections, all groups included alternative conceptions. They even specified how to use these ideas in each activity. Furthermore, the neuroscientific knowledge also appeared in the *Introduction* section of every final proposal. In particular, Groups 1, 2 and 4 used neurosciences to explain the resistance of misconceptions. Additionally, Groups 2, 4 and 5 mentioned that these biological features should be considered by teachers, since it would help them understanding children's difficulties of learning.

In the *Objectives* section, every group, except for Groups 2 and 5, indicated that children should be taught the neurophysiological component of alternative conceptions, since this would help them understanding factors that hinder their learning process. Furthermore, in the *Contents* section, Groups 2, 4 and 6 proposed some neuroscientific questions that students should understand (e.g., G4: "Distinguish between the sensations of "cold" and "heat" and the corresponding scientific concepts"). Furthermore, Groups 2 and 4 proposed some alternative conceptions on heat and temperature to be included as teaching contents. The other groups only considered academic topics; that is, the contents on physics of a traditional scholar curriculum.

In the *Evaluation* section, Groups 1, 2 and 4 indicated the necessity to include neuroscientific details in the explanations of natural phenomena. They suggested that students should understand the differences between thermal concepts and how we feel them.

5 Concluding remarks

Results indicate that the incorporation of neuroscientific content into the training course stimulates the application of misconceptions in every section of students' teaching proposals. Furthermore, prospective teachers mentioned that it is useful to know the physiological origin of alternative conceptions, since this helps them understanding children's difficulties of learning.

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