Design and trialling of an educational sequence on surface phenomena for university students

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Abstract. In this work we present the design and trialling of a teaching-learning sequence (TLS) for university students on surface phenomena. The TLS is aimed at favouring in the student a gradual process of active construction of knowledge. The theoretical framework chosen for the TLS combines concepts from psychology, physics education research, and epistemology. Students use inquiry-based methodologies to identify hypotheses, practice the use of critical thinking, and consider alternative explanations for the interpretation of proposed physical situations. The aim is to combine the scientific and students' perspectives to maximize learning.

Introduction

In recent decades, a strong trend towards the renewal of teaching of scientific disciplines has emerged, with particular reference to the involvement of students in pedagogical activities based on a constructivist approach. In the research presented here we provide an overview about how to develop and validate a TLS with university students on surface phenomena strongly based on active learning methods. The TLS is developed on the basis of the results of a previous trialling, that highlighted the need for enhancing the use of interactive simulations in education, relating their results to experimental ones. The trialling of the educational path is done on students attending the second and third year of three different engineering courses at the University of Palermo, Italy. The students are involved in a extracurricular activities, lasting 30 hours. The research focuses on how to enhance active knowledge construction, fostering students' appropriation of physical concepts, rather than witnessing a simple transmission of knowledge. Various processes have been suggested in the literature to describe the conceptual changes that occur in students when they become involved in physics lessons and tends to approach a branch of knowledge that they never dealt with. The peculiarity of this TLS lies not only in proposing physical contents not covered within the curricula, but knowing how to offer them to students in an emotionally and cognitively engaging way.

Theoretical framework, research and research questions, original aspects

The theoretical framework used in this research activity essentially focuses on the constructivist idea introduced by authors such as Vygotsky and Piaget. The construction of the project is inspired by the Educational Reconstruction model [1], and is aimed at both reconstructing the scientific content, and allowing students to carry out a self-regulated validation and verification process during the learning phases. The methodology that is applied to the group of university students involved in the trialling is centered on Inquiry Based Science Education. It allows students to ask themselves questions about the observed physical phenomena, thus encouraging a critical/constructive approach to the problem and favouring peculiar productive/cognitive aspects such as the development of a growth mindset. Moreover, it can help the students to develop divergent/convergent thinking and encourage the production of creative ideas. In order to be able to investigate correctly all the possible aspects that come into play when students learn, we designed a detailed scheme on what we mean for "learning in Science" [2]. This scheme includes what we have selected as three salient "dimensions" of learning. From each of them, subdimensions were determined which allow us to understand, study and examine the large amount of data collected and above all to verify whether, to what extent and in what way our TLS can be considered effective to foster students' learning. In this paper we will focus on a single subdimension, namely the development of student reasoning lines aimed at interpretations of physical phenomena. So, the main research question addressed in this paper can be stated as "To what extent does an educational path based on laboratory activities and interactive simulations manage to encourage the development of reasoning lines aimed at interpretations of physical phenomena?".

Methods and findings

During the TLS trialling several tools were used to collect data to analyze: worksheets used during work group in laboratory and simulations activities (based on the "smoothed particle hydrodynamics" (SPH) algorithm [3]); two open questionnaires (one regarding general knowledge of physics, and another, regarding topics specific to the course); audio recorded discussions, developed during brainstorming activity and large group activity. A study with this large dataset, based on a mixed analysis, was conducted [4], in order to get insights into how students reason when fronting proposed situations. A thematic analysis [5] was conducted on the data coming from worksheets and audio recordings to reconstruct in detail all the ideas on surface tension expressed by the students during the entire duration of the TLS. In order to analyze the answers given by the students to the questionnaires, we first categorized the answers by means of a phenomenographic analysis [6]. This type of analysis allowed us to discern category models that describe the experience of the phenomenon in terms of essential meaning for the student. Three distinct categories were identified on how the students perceive the request to explain a proposed situation [7].

Conclusion

The results of the TLS trialling, with respect to the subdimension we chose to study here, highlighted how the learning activities influence the way the students face the various pedagogical situations of the TLS. During the presentation we will present these results and discuss some implications for learning of the research.

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