problems has the potential to facilitate communication of the concepts that we intend to teach; to make the students closer to the subject of study; to promote the development of inductive / deductive reasoning, because through the solutions presented by students, teachers come to know the actual level of development of the students and act in the zone of proximal development, increasing the development of the individuals learners. The purpose of the research, from the assumption outlined here, therefore, was to evaluate under the light of Vygotsky's theory of the learning development of the individuals of this research mediated by tools and signs arising from the natural science.

An Inquiry-based approach to the Franck-Hertz experiment

Nicola Pizzolato, Dominique Persano Adorno and Claudio Fazio
Department of Physics and Chemistry, University of Palermo (Italy)

Nanophysics and nanotechnology are rapidly advancing, together with their significant applications and implications for everyday life. The practice of scientists and engineers is today exerted within interdisciplinary contexts, placed at the intersections of different research fields, including nanoscale science. Thus, the education of science/engineering undergraduates is fundamental to contribute to the scientific and technological progress. Several challenges are related to a full understanding of scientific concepts at nanoscale. The development of the required competences is based on an effective science and engineering instruction, which would be able to drive the students towards a deeper understanding of quantum mechanics fundamental concepts and, at the same time, strengthen their reasoning skills and transversal abilities. On the other hand, a careless simplification of the sophisticated concept of nanoscience could generate misconceptions, lead to superficiality and risk of misrepresenting.
In this study we present the results of an inquiry-driven learning path experienced by a sample of 15 selected engineering undergraduates engaged to perform the Franck-Hertz experiment. Before being involved in this experimental activity, the students received a traditional lecture-based instruction on the fundamental concepts of quantum mechanics. Despite the instructor's introduction to specific technological/engineering-based contents during the course, the students' answers to an open-ended questionnaire, administered at the end of the lectures, demonstrated that the acquired knowledge was characterized by a strictly theoretical vision of quantum science, basically in terms of an artificial mathematical framework having very poor connections with the real world. This could be ascribed to the many difficulties that students demonstrated to have in order to deal with concepts at scales in which they cannot have a direct experience in their everyday life, especially at microscopic and sub-microscopic scales. Moreover, students prefer to conceptualize matter as being continuous rather than discrete.
In order to fulfil these lacks, the students were invited to actively participate to an experimental activity within an inquiry-based learning environment at the Laboratory of Condensed Matter Physics at the Department of Physics and Chemistry of the University of Palermo. The Franck-Hertz experiment was introduced to the students by starting from the problem of finding an experimental confirmation of the Bohr's postulates asserting that atoms can absorb energy only in quantum portions. By following the lines of a scientific inquiry, the students, working in group, performed a questioning activity that naturally guided them throughout the steps of the Franck-Hertz experiment. The whole activity has been videotaped and this allowed us to deeply analyse the student perception's change about the main concepts of quantum mechanics. At the end of their inquiry-based learning path the students were also asked to answer to a structured interview with questions similar to those proposed by the initial questionnaire.
First of all, video analysis clearly demonstrated a great participation and motivation to learn, both in terms of useful discussions and scientifically relevant questions. Moreover, we have found that the reasoning effort asked to the students to successfully perform this learning experience

successfully reinforced their understanding of the quantum mechanics fundamental concepts. This experience definitely favoured the building of cognitive links among student theoretical perceptions of quantum mechanics and their vision of quantum phenomena, within an everyday context of knowledge. In conclusion, our findings confirm the benefits of integrating traditional lecture-based instruction on quantum mechanics with learning experiences driven by inquiry-based teaching strategies.

A fresh hands-on approach to improve students' understanding of introductory thermodynamics (continued)

Tom Lambert
PONTOn vzw, Belgium

The test and exam results from 4th year secondary school students (generally 15 years old) proved year after year a poor understanding of introductory thermodynamics topics that were taught. The results were remarkably lower than other physics topics that were covered in the same years. This poster presents a fresh hands-on approach to improve students' understanding, using an small scale research project and a visit to the local DIY (do-it-yourself) store, combined with an alternative evaluation and assessment method. This resulted in better results. A comparison and a SWOT (strength, weakness, opportunities and threats) analysis of the project will be presented. Also, the results over the different years of the project shall be presented.

Mathematical Model of Didactic Structure of Physics Knowledge embodied in Physics Textbooks

Eizo Ohno
Hokkaido University, Japan

Transforming from scholarly knowledge of physics to "physics knowledge to be taught" is a fundamental process to design physics curricula. "Physics knowledge to be taught" has a carefully versioned form of knowledge, adapted to be appropriate for teaching physics in particular context. "Physics knowledge to be taught" is transformed further into teaching materials. Teaching materials are actually learnt by students in their classrooms. "Physics knowledge to be taught" has the key role of connecting scholarly knowledge of physics and teaching materials.

The author has proposed a mathematical model to describe the didactic structure of "physics knowledge to be taught" [1, 2]. The mathematical model was developed on the basis of on the basis of the channel construct described by Barwise–Seligman’s channel theory [3]. The basic components of "physics knowledge to be taught" form are represented via the notion of classification. The classifications are mathematical sets of "physics knowledge to be taught" related to the events and activities which students experience in their science classroom. Those classifications are connected to each other with the functions called infomorphisms. The infomorphisms show information flow between classifications. The relational structure of the “physics knowledge to be taught” form comprises linked classifications and is modeled as a distributed system. A diagrammatic representation of the didactic structure of "physics knowledge to be taught" was obtained from a series of learning activities. The learning activities, such as experiments, observations, and problem-solving exercises, were classified, and the relational structures between them were considered as distributed systems. Classifications called cores play a key role in information flow in the distributed system.