Physics of the Earth system: design and implementation of an experimental educational module for high school students

Lodovico BARBERIS, Daniela MAROCCHI, Marta RINAUDO, Marina SERIO,

Università degli Studi di Torino, Dipartimento di Fisica, via Giuria 1, 10125 Torino, Italy

Abstract. How the solar radiation reaches the top of Earth's atmosphere? Which are the main issues while this energy comes down to the soil and how does the Earth respond, varying its characteristics? Which are the main motions in the atmosphere and which are the main data useful to describe these phenomena? How can models for weather and climatic forecasting be developed? We try to respond to these questions by an educational path for high school students.

1 Introduction

This project, specifically designed for high school teaching purposes, is aimed at exploring the physical processes underlying the atmospheric phenomena and includes several important physical concepts. The project is innovative because topics, sometimes already studied during the previous school years, must be applied to situations very different from the ones presented in the textbooks [1].

It requires the assembly of knowledge, skills and experiences related to different fields, as well as the design of an experimental path without sophisticated instrumentation. This activity has a remarkable interdisciplinary nature: for example the analysis of on-line data coming from weather stations makes possible an interaction with the IT teachers and is useful to encourage the students to use consciously spreadsheets.

2 Educational project

The project was included in a master degree thesis and consisted in two phases. The first one involved 5 high school students at the end of the fourth year, participating to a one week summer internship at the Physics Department in Turin. Four topics related to physics of atmosphere were chosen and for each topic we developed a preliminary test (designed to explore the students' basic knowledge regarding the fundamental concepts of the lesson and the possible outcome of the proposed experiment) [2], a theoretical introduction (aimed to provide the knowledge to consciously perform the laboratory experience), followed by mathematic exercises and lab experiments.

The main topics chosen are:

a. The concept of radiation and linked phenomena, followed by the irradiation with the same source of light of cylinders of different colors with the same light sources [3]. This experiment, despite its simplicity, allows the introduction of the concept of modeling. Furthermore it introduces to the ways of solar energy propagation and to the response of ground according to its properties.

b. A simulation of the greenhouse effect, aimed at observing the temperature variation with a planet model without greenhouse gases to a model with greenhouse gases. Experimentally, the greenhouse effect is simulated by covering with a plastic cover a heated black metal plate: the students have to record and analyze the temperature variation of the plate.

c. The atmospheric motions on a global scale, introducing the explanation of precipitations, cloud formation and their classification. The experiments regard the motion in a convective cell and the formation of a cloud inside a bottle.

d. Physical models used in meteorology and climatology, and the introduction to the complexity of meteorological forecasting. Using the data gathered from the Department's weather station, it is possible to test the use of these models to analyzed data from the past [4].

At the end of the internship the students acquire several notions in the field of atmospheric sciences, understanding the way these studies need knowledge in many areas of Physics. The analysis of data coming from meteorological stations encourages them to better organize the information acquired during the theoretical lessons, with a better expertise of the technical, scientific and informatics language. The combination of experimental and theoretical parts allows the comprehension of the working method adopted by professionals in this field.

In the second phase, the project was proposed, partly reduced and simplified according to the teachers' recommendations, to nine first classes of the catering institute "J.B. Beccari" in Turin. These students never approached a Physics subject before, so the goal was dual: to teach the key concepts of the atmospheric phenomena and to show that Physics task is to observe and describe, also in a mathematical language, physical events that occur in everyday life [5] [6].

In the post-test (25 closed-answer questions) the results indicate an improvement of knowledge on the greenhouse effect ($p=0,0037$). Furthermore 82% of students consider stimulating and clarifying the laboratory experiences, and 62% consider clearer some environmental problems, often subject to social and political discussion especially through the media.

3 Conclusion

From the final evaluations it emerges that the study of topics related to real events stimulates the attractiveness in scientific concepts and activities. At the national congress DIFIMA (Turin, October 2017), mathematics and physics teachers asked that the experience will be re-proposed as an internship on June 2018.

References

[1] W. Space, Climate Physics: Using basic physics concepts to teach about climate change, *Science Teacher*, **74**(6) (2007), 44-48.

[2] T. Miléř, J. Hollan, J. Svobodová, Climate Change Education for Physics Teachers, *ICPE-EPEC Conf. Proc*. (2013), 561-569.

[3] U. Besson, A. De Ambrosis and P. Mascheretti, Studying the physical basis of global warming: thermal effetcs of the interaction between radiation and matter and greenhouse effect, *Europ. J. Phys.*, **31** (2010) 375- 388.

[4] G. Tasquier, O. Levrini and J. Dillon, Exploring students' epistemological knowledge of models and modelling in science: results from a teaching/learning experience on climate change, *Int. J. Science Educ.*, **38**(4) (2016), 539-563.

[5] Richard A. Muller, *Physics for future Presidents: the Science behind the headlines,* Norton&Company, N.Y., 2008 (cap. V)

[6] H.C. Busch, Using Environmental Science as a Motivational Tool to Teach Physics to Non-science Majors, *Phys. Teach.,* **48** (2010), 578-581.