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PHYSICS EDUCATION

NON-FORMAL SCIENCE EDUCATION PROMOTING LEARNING THROUGH EXPERIMENT

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Abstract. The educational project *Day of the Earth* had promoted real/virtual experiments as well as ecological ones. The project was carried on between 2007 and 2010 and was organized by Theoretical High School *Ion Barbu* in partnership with Center for Science Education and Training (CSET) and the Faculty of Physics - University of Bucharest. The project was carried on as a contest and was addressed to students from the first to twelfth year of study, as well as to teachers in both primary and secondary education. This work presents the statistics of the number of participating students and teachers in the four project editions, as well as the evolution of the number of works with an experimental subject as compared to that of ecological projects. The processed results of the students' and teachers' answers to the questionnaire intending to assess the project relevance (applied to the 2010 edition) are also presented.

Key words: hands on approach, teaching physics, primary school, secondary school.

1. INTRODUCTION

According to the widely accepted definition, non-formal education is the learning that occurs in a formal learning environment (workshops, symposia, extracurricular courses and seminars, etc.), but that is not formally recognized within a curriculum or syllabus framework.

After the 1990 many studies have shown an alarming decline of youth interest in learning basic sciences and mathematics. The Maps association conducted a survey regarding the number of physics graduates in 1998 and 2002 and offered a report to the European Commission in 2005 [1]. The report showed that, in Europe, between 1998 and 2002, the number of physics graduates dropped by 15%.

Most researchers agree that the declining of young people interest for science studies is largely due to the way science is taught in schools, and suggest several ways in which this attitude can be changed [2]. In this respect, the teachers play a

key role in the renewal of basic science education. To improve the quality of their teaching and increase the student motivation, the teachers must learn attractive practical methods like: "Hands on" (or "La main à la pâte" in French version), Inquiry-Based Science Education (IBSE) and Problem-Based Learning (PBL) [3].

In Romania, besides the low interest of students in studying basic sciences, it is also encountered a dramatic reduction in the level of knowledge in natural sciences at the end of primary school [4] and at the end of secondary school, too [5]. This situation requires an emergency intervention, but, in order to be effective, this intervention should start with the curriculum and teaching strategies in elementary, secondary, and high schools.

We believe that the creativity of teachers can be effectively stimulated by their participation in experimental and interdisciplinary projects [6, 7].

2. THE PROJECT *DAY OF THE EARTH*

Between 2007 and 2010 the first author coordinated the project *Day of the Earth,* part of the larger project entitled *Inquiry-based science education for primary and secondary school teachers – Discover!* This project, funded by the European Social Fund through the Operational Sectorial Program Human Resources Development, is coordinated in Romania by the Center for Science Education and Training (CSET–INFLPR, Bucharest-Măgurele) [8–12].

The *Day of the Earth* project was organized by the Theoretical High School *Ion Barbu* – Bucharest, in partnership with CSET and the Faculty of Physics - University of Bucharest.

The project objectives were as follows: a) revitalizing the students' interest for the study of basic sciences, b) disseminating the good practices in the field of teaching basic sciences and c) promoting ecological education.

The project was carried on as a contest and was addressed to students from grades I–XII, as well as to teachers in both primary and secondary education schools.

The project was conducted in two stages, as follows:

1. First stage: *Earth Day Symposium*, in 2007, with the sections: Geophysics, Astrophysics, Ecology, Posters, and Drawings and photos with an environmental message.

2. Second stage: *International Science Fair, at Earth Day,* in 2008–2010, with the sections: Real Experiments, Virtual Experiments, and Ecology Projects.

At *Earth Day Symposium* each scientific section has benefited from presentations supported by professors from the Faculty of Physics, University of Bucharest, Polytechnic University of Bucharest, and National Institute for Lasers, Plasma and Radiation (INFLPR)-Bucharest.

The students have presented their personal projects in each scientific section and the assessment of their scientific work was made by the same academic staff.

At primary and junior levels most works tackle environmental problems. At high school level, the number of ecological papers was almost double as compared with the number of works from the other two sections.

We believe that the large number of ecological papers is due to an accessible level of understanding and to the real interest of both students and teachers in environmental problems facing society today.

First author of this paper also coordinated several works which were presented on the same occasion. The most valuable, in the authors' opinion, were the projects *Transforming planet Mars for accessible life by active astrophysics*, *A star's destiny* and *Meteorites impact*.

In the second stage of the project, *International Science Fair at Earth Day,* the students have presented experiments, devices or experimental arrangements that illustrated physical, chemical or biological phenomena, and their technological applications. The students have also presented the activities carried out within the ecological projects and their results.

At primary and secondary education levels, the students have conducted simple but spectacular and interesting experiments, applying the *Hands on Science* method.

At high school level, the students coordinated by the teachers, applied the method IBSE to answer questions like: *How can I get the plasma in the classroom? How to view the deviation of electron beams in electric and magnetic fields*? *What is the role of carbon dioxide in global warming?*

The number of participating students and teachers in the project four editions was the following (Fig. 1).

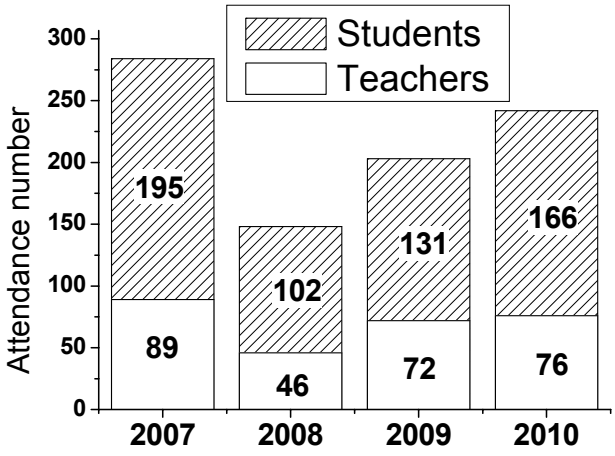

Fig.1 – Attendance number (students and teachers) in the fourth editions of the project.

In all four years, the students that have participated in this project came from the same educational environment.

We can see that in 2008 the number of participants is smaller by almost 50 % than the number of participants in 2007. We believe that what explains this dramatic decrease of experimental methods is the use of the classical method of chalk and blackboard teaching.

One of the goals of the project organizers was to involve an increasing number of primary school students. The scientific education of the students should start at early ages, being initiated in the methodology of scientific investigation and how to conduct as many experiments as possible, in order to have an idea about the phenomena and the laws of the physical world, using materials that come handy to them.

The graphic below (Fig. 2) shows the evolution of the number of participating students in the I-IV grades.

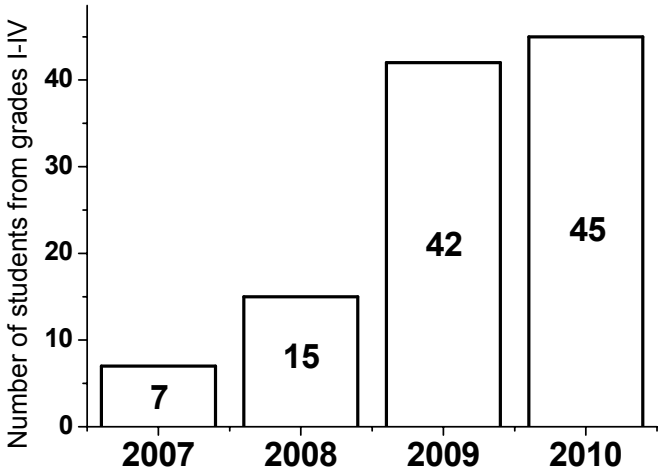

Fig. 2 – Evolution of the number of project participating students in the I-IV grades.

We can note that, in 2007, the students from primary school have participated in a small number, representing an average of 3.5 % of the total number of participants. The number of primary school students has increased in the last two years, reaching an average of about 25 %, in 2010.

The evolution of the number of experimental works, related to ecology projects, has been another target on the list of the organizers (Fig. 3).

We can observe a steady increase of the total number of papers, along with a constant increase of ecological projects that were presented. The authors believe that this increase is a consequence of the methods used in teaching sciences (mostly in physics) in our schools during the last three years.

To evaluate the results of the project, at the end of the 2010 edition, the participants were asked to fill up the following questionnaire.

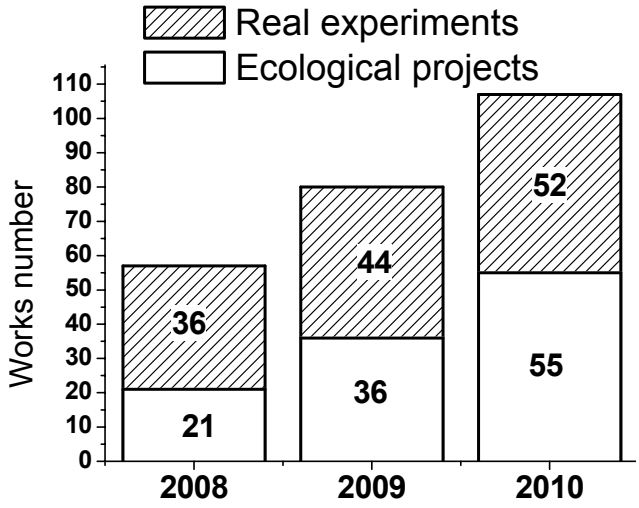

Fig. 3 – The evolution of the number of experimental works related to ecology projects.

3. QUESTIONNAIRE 2010

On a scale from 1 to 10, please indicate in what way the presentation of real experiments during the Science Fair, was useful both for students and teachers.

On a scale from 1 to 10, please indicate in what way the presentation of virtual experiments during the Science Fair, was useful both for students and teachers.

On a scale from 1 to 10, please indicate in what way the presentation of activities regarding the ecological projects was useful both for students and teachers.

On a scale from 1 to 10, please indicate in what way the participation in such experimental and/or project based activities has influenced your way of teaching/ learning sciences in the classroom?

Please indicate, in which grade, it is useful to perform simple, interesting experiments that can be done using every day materials from the student's environment (addressed only to teachers).

From all participants, a number of 51 students and 14 teachers gave answers to each question (Table 1).

Table 1

Results of the questionnaire

Number of students/ teachers	Average grade for real experiment	Average grade for virtual experiment	Average grade for ecological projects	Average grade concerning influence (question 4)
51 students	8.75	8.08	9.24	8.56
14 teachers	9.79	9.50	9.79	9.77

Concerning the usefulness of simple experiments using every day material from the students' environment (the 5th question) approximately 70 % of teachers believe that these kinds of activities should be used at all levels, from primary to high school.

We notice also the following conclusions:

- The projects in ecology were considered by the students the most useful activities.
- The teachers considered that the importance of real physics experiments is equal to that of the ecological projects.
- The students and the teachers are thinking that the virtual experiments are less useful as compared with the real experiments and the ecology projects.

4. NON-FORMAL EXPERIMENTS

The experiments presented by students are easily to make, spectacular, but the phenomena involved are often complex, beyond the knowledge they acquired in the classroom. Explanations of phenomena presented in the experiments are accessible to students, but they can be enriched in the coming years, with the acquisition of higher knowledge.

In the described project, our students have conducted experiments whose source of inspiration was very large: books of science popularization, Internet, teacher's or parents' experience.

For instance, at the primary school level, we proposed a simple experiment that consists in *burning a candle inside a jar placed upside down, in a dish with a thin layer of water*.

One of the favorite topics of lower secondary school pupils was the *atmospheric pressure*. In this issue, they presented a series of spectacular experiments which highlight the action of atmospheric air on objects around us, like *a soda can is crushed by air pressure*.

High school students have expressed their concerns about environmental health by involvement in an environmental project with the subject *Drinking water plant*. The project started with a visit to the drinking water plant in Roşu (a village near Bucharest) and ended with the design and construction of a functional model of such a plant.

Students' drawing of their functional layout of the drinking water plant, as it was designed in the project diary, is given in Fig. 4.

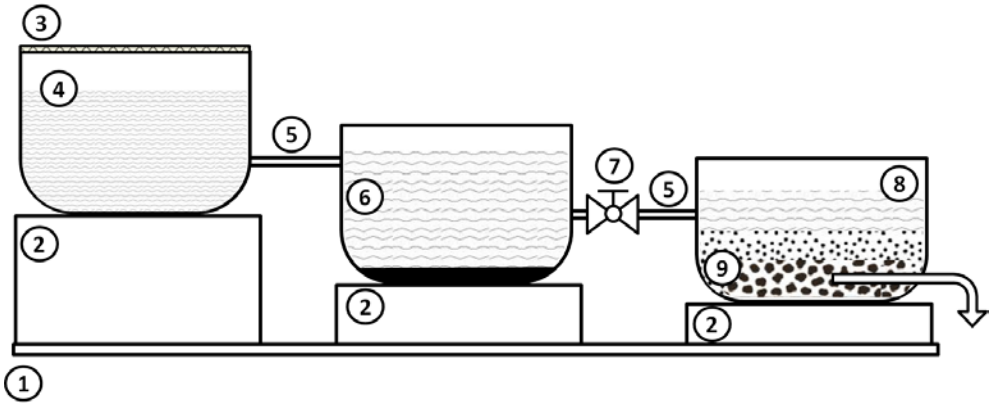

Fig. 4 – Small-scale model of the drinking water plant (a sketch performed by students in the project diary). The numbers in figure represent: 1) board, 2) supports, 3) sieve, 4) entry tank, 5) water pipes, 6) decantation tank, 7) control valve (tap), 8) final tank, and 9) sand and gravel filter.

Finally, the students tested the functionality of their project. They have prepared dirty water using mud and leaves and then they poured it through a sieve in the first tank. Under the action of a coagulant (liquid glue), the very fine particles, in suspension in water, gather in the form of flocculent sludge at the bottom of the decantation tank. After the process of decantation, the clear water is sent to the filtration stage. Water passes through layers of sand and gravel and the impurities remain in the sand. At the end of this process students have achieved clear water.

Besides the satisfaction of seeing their work accomplished, the students have acquired new knowledge: they have learned about the complex phenomena in the process by which drinking water is obtained.

5. CONCLUSIONS

• Project *Day of the Earth* offered, in an attractive manner, an opportunity for non-formal teaching and learning sciences to a total number of 677 students and 283 teachers.

• The students, guided by teachers, looked for experiments they considered interesting, using as resources Internet and/or books, encyclopedias, making efforts to understand the principles and laws involved in the chosen experiments.

• Real exchange of experience took place among the students and the teachers at primary, secondary, high school, and university level.

• One of the main project benefits was the fact that the primary school students have enthusiastically participated.

• Additional activities like drawing exhibitions, posters, photos or ornamental objects represented expression modes of gifted students.

• The project has proved to be a good way of involving school community (in the broadest sense) including parents, researchers and academics from research institutes and universities.

• The very small number of primary school students involved in the project, during the first two years, indicates a low interest of the teachers in the scientific education of their pupils.

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