

ACTIVITIES OF A CROSS-INSTITUTIONAL GROUP TO PROMOTE PHYSICS

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ABSTRACT: the “Working Group in Physics” of the Servicio de Formación Permanente de la Universidad de Valencia (University Permanent Training Office), constituted in 1999 and formed by high school teachers and university professors of physics, has coordinated a variety of initiatives in order to counteract a decaying interest in the physics studies and to contribute to the improvement of physics teaching and learning at the high school level. Physics training courses, university-high school exchange sessions, a program of portable experiment suitcases or practical workshops are some of the activities - unique in some cases - which are presented and analyzed in this article in the context of the general physics panorama.

The “Working Group in Physics” (WGP) is a crossed-institutional group integrated by high school teachers and university professors of physics. It was constituted as a group open to any teacher wishing to contribute to public scientific literacy and with the goal of promoting physics studies and contribute to the improvement of the teaching and learning in physics at high school level.

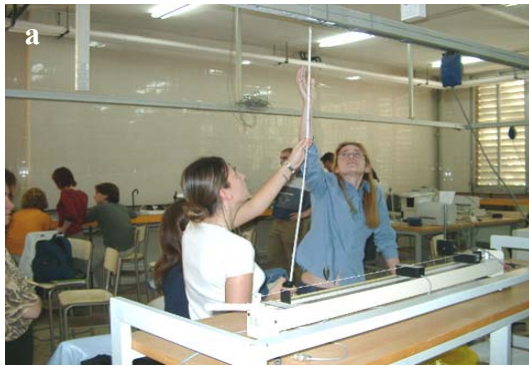
In order to fully understand the purpose of the activities carried out by our group, it is necessary to start with some premises. Simultaneously with the creation of the group, the high school physics in Spain has suffered a deep change, with the generalized implementation of a new educational system that redefined the contents of the physics high school curriculum¹. It must be pointed out that traditionally, physics at high school has always been studied in a *physics+chemistry* integrated subject, being the last high school year the only one in which physics is studied on its own (in fact, a great percentage of high school physics teachers are chemistry graduates). The new educational system mentioned above has changed the situation of physics in two senses: a) It has rendered the subject optional for most student curricular itineraries. A more recent modification of such system will allow a student to pass through all high school stages without the slightest contact with physics and b) the physics contents have been drastically changed, with a strong reduction of the *classical* parts and a shift versus the so-called *modern physics*. Such choice of contents constitutes a generalized and controversial trend², which generates a great need of in-service training courses which is hardly satisfied by the administration. On the other hand, the non compulsory character of the subject has led to an extraordinary decrease in the number of students choosing physics at High School (either in the compulsory educational stage or in the *baccalaureat*¹), not to say at a University level. Furthermore, the importance given in the physics curriculum to the guided observation of phenomena and the experimental (also quantitative) practice is very scarce at all levels. Experimentation requires an institutional supplementary effort which exceeds the mere acquisition of apparatus. Such support has been usually absent and the successive curriculum changes have scarcely modified that trend.

"The Working Group in Physics" has carried out different activities which reflect the belief that a generalized scientific literacy can only be achieved if the link between the concrete (phenomena and experiments) and the abstract level (models to explain them) is not broken^{2,3}, and that the students must be actively involved in science through a personal discovery and investigation of the natural phenomena together with a guided rationalization^{3,4}. The goal of our group is, hence, the improvement of the teachers' hands-on experience and conceptual understanding of physics, as well as the promotion of physics at a high school level, through the planning and development of a variety of training activities, including those needed for the new Spanish physics curriculum mentioned above.

Our group has developed such activities in cooperation with different institutions, with a stable partnership with the Faculty of Physics of the University of Valencia, the department of Applied

Physics of the Polytechnic University of Valencia and the Permanent Training Service (SFP) of the University of Valencia, to which our group has been ascribed from the beginning. In the following, we explain in detail the organization and objectives of the different activities we have already carried out.

1. **Physics training courses**, addressed to high school teachers, covering in a comprehensive way the contents defined in the Spanish new physics curriculum. In these courses, special attention has been paid to the introduction of physical concepts through experiments. In particular, low-cost and versatile demonstrations that the students are able to build by themselves in the classroom or as homework have been developed for each course, in order to illustrate basic phenomena in a simple and clear way. When possible, the quantitative analysis of the experimental results has been emphasized. We believe that the decision of limiting the courses to small groups of trainees (up to 30 distributed in two groups) has greatly contributed to their success, as it has favoured the discussion and a first-hand manipulation of the demonstrations and laboratory material. Following this organizative scheme, courses like *Workshop for Physics Experiments for the New High School Curriculum (LOGSE): Mechanical and Electromagnetic Waves*, *Presentation of Scientific Concepts with Power Point*, *Practical course of Quantum Physics (basic concepts and experimental developments)* or *Practical course of Electromagnetism* have been concluded with great success. Second editions of some of the courses have been organized in order to satisfy the extant demand. These are the only physics in-service teacher training initiatives which have been offered in the recent years in our region. The contents of the different courses have been published on various CD-ROMs and distributed to the trainees for their future use. This material won the second prize in the national edition of the "Physics on Stage" 2002.
2. **"Physics Exchange Program"**. This project consists in the preparation of a laboratory session for high school students in the undergraduate laboratories of the Physics Faculty. The goal pursued through this activity is twofold. First, this hands-on activity improves the students understanding of the fundamental physical phenomena, enhancing the relation between the physical models developed in the classroom to explain the real world and the actual observable phenomena. Second, the active participation of the students in experimental work possibly contributes to their future scientific orientation. This is specially true in the case of 16 year-old students who have chosen a *physics+chemistry* subject in their first year of the *baccalaureat* and must decide about choosing a physics subject in the second (and last) year. The general lines of the activities to be performed by the high school students were designed jointly by High school teachers and University professors involved in the WGP. The scripts (adapted to the high school level) and methodology were developed by the professors of the Optics and Applied Physics departments, in charge of the laboratory activity, while the high school teachers involved in the experience worked out the experiment contents with their own students. In fact, teachers were invited to a preliminary practical session in which the proposed experiments were thoroughly explained and the conceptual and practical difficulties identified. In the laboratories, after a brief introduction covering the basic physical concepts of each experience, the students (a maximum of 20) are organized in couples and are given two or three hours (depending on the laboratory) to perform the experimental work. Their teachers, as well as the university professors in charge, are constantly monitoring their experimental work. The results are finally reflected in a report that each couple gives back to their teacher, who evaluates it, incorporating the mark to the students' final grade. The critical comment of students and teachers, which constitutes the evaluation of the experience have been very positive, and a significant number of students decided to undertake physics in the last year of high school. The following photographs reflect the students' work in the Mechanics (a) and Optics (b) laboratories.



3. **“The Experiments Cupboard”**. This is an experimental project designed to promote the use of physics demonstrations (in a quantitative, as well as qualitative way) at high school. We have developed three experimental setups covering different subjects (mechanics, electromagnetism and optics) of the physics high school curriculum. The materials and instructions needed for each experiment fit inside a rolling suitcase that can be easily transported. The project includes a script with experimental suggestions as well as an evaluation sheet that high school teachers must fill after the experience. High school teachers can sequentially borrow the experimental cases, use them in the classroom and give them back for a successive use. This project has been developed in collaboration with different high school centres with good results, and will constitute the basis for a wider project in which a complete collection of experiments and demonstrations will be shared by a greater number of centres. The use of the experiment cases by the teachers requires their previous participation in a training workshop where they prepare the experimental set-up on their own and reflect on the best way to use the *demo* in its theoretical context. In such workshops, special emphasis is given to the quantitative use of the experiments, so as to illustrate the predictive character of physical models to real phenomena. The use of these experimental cases has already been presented in different workshops on Physics and Science Education (*Workshop on Physics and Chemistry: motivation and didactics for teaching* (Valencia 2002), *First Workshop about Physics and Chemistry Teaching in High school* (Barcelona 2003)).

In addition to the courses and projects already mentioned, the group has been involved in different workshops on Physics and Science Education. To accomplish the goal of involving students in the active discovery of science phenomena, we believe teachers must acquire confidence in the practical construction and conceptual interpretation of easy-to-mount demonstrations that they can later work out in their classroom. With this idea in mind, several contributions were developed for workshops like the *First and Second Workshop on Didactics and Scientific Education* (Sagunto 2002-2003), *Workshop on Physics and Chemistry: motivation and didactics for teaching* (Valencia 2002) or *First Workshop on Didactics and Scientific Education* (Barcelona 2003). As an example of the organization of our hands-on activities, we describe here the experiences proposed under the name *Let's see what we can find at home!: Simple Physics Demonstrations*. This practical workshop was addressed to primary and high school teachers, who built by themselves three demonstrations under the careful supervision of different WGP members. In particular, we explained the physics underlying the operation of a simple motor (electricity), the diaphragmatic breathing (differences of pressure, thermodynamics) and the pinhole camera (optics). Simple circuits and conductivity (electricity), wave phenomena with *slinkies* or the seasonal variations on Earth were considered as topics in a second edition of the same workshop. The trainees were given general and individual explanations on the underlying physics and links with other related scientific fields. The possible pedagogical uses of these demonstrations were investigated through fruitful discussions with the participants. It was found essential to convince the teachers to build their own working demonstrations individually, a task that is only possible if teachers are organized in small

groups (a maximum of 10 supervised by one instructor). As pointed out in the introductory paragraphs, there is an enormous lack of experimental tradition in teaching. All the mentioned demonstrations are well-known and simple ones. But the difficulty consists in overcoming the natural tendency to avoid any experimental contact, an attitude which finds its roots in such tradition, the absence of training and, last but not least, lack of time and means. We have found very positive that, at the end of the session, the trainees can take away their just made ready-to-use demos. We are very much concerned about the proper use of such demos, in a contextualized conceptual scheme, and not as mere attractions to which no rationalizing effort is done. For that reason we usually distribute written hand-outs in which a precise conceptual use of the demos is proposed.

The “Working group in Physics” has been also involved in the organization of numerous activities related to physics education: high school students' visits to the Physics Faculty, debate sessions about the new physics and chemistry curriculum or visits to high school centers to show the use of new technologies in science teaching. Future activities will include courses for primary school teachers in which the experimental demonstrations will constitute the nucleus around which we will conduct the conceptual explanations. Another initiative we have taken in consideration is that of visiting different high school labs in order to evaluate the available material and organize workshops in which teachers prepare different experimental setups using their own set of instruments.

To conclude, we consider that an important feature of our group is its cross-institutional or hybrid character, which allows a privileged viewpoint and a notable action capability that has led, in our opinion, to the success of our initiatives and their increasing demand, specially those concerning experimental demonstrations. We are very much concerned with the seriousness of the situation, and we are aware that the roots of the problem start in the early educational stages, to which we will address a part of our future work.

¹ The previous system used to structure the educational life in a primary school period (EGB, from 6 to 13 years old) and an optional 4-year high school period or *baccalaureate* (BUP+ maturity, from 14 to 17) or a professional itinerary in alternative. The new LOGSE system contemplates three periods: primary school (6 to 11), compulsory secondary school (ESO, from 12 to 16) and an optional two-year *baccalaureate* previous to university (or a professional stage in alternative). An even newer modification of that system (LOCE) will be soon applied. It is not the scope of this article to judge or discuss the benefits of the different structural changes, mainly because they should not necessarily have resulted in a drastic change of the physics curriculum, as in fact it has.

² Russo, Lucio, *Segmenti e bastoncini. Dove sta andando la scuola*, Feltrinelli 1998.

³ Arons, Arnold B., *A guide to introductory physics teaching*, John Wiley & Sons, 1990.

⁴ Frova, Andrea, *La Fisica sotto il naso*, Superbur saggi 2001.