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# Valencian Network of Educational Innovation in Optics

A. Pons-Martí[1], J. C. Barreiro[1], M. Fernández-Alonso[2], Ll. Martínez-León[2], M. H. Giménez[3], and J. A. Monsoriu[3]

[1]*Grupo de Innovación Docente en Óptica. Dep. Óptica, Universitat de València, 46100 Burjassot, Valencia, España. amparo.pons-marti@uv.es*

[2]*Equipo de enseñanza y divulgación de la Física, Departament de Física/INIT, Universitat Jaume I, Campus de Riu Sec, 12071, Castelló de la Plana, España.*

[3]*Departamento de Física Aplicada, Escuela Técnica Superior de Ingeniería del Diseño, Universitat Politècnica de València, 46022 Valencia, España.*

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**Abstract**

The Valencian Network of Educational Innovation in Optics consists of three groups from the Universitat de València, Universitat Jaume I, and Universitat Politècnica de València. The participants in the network present an extensive background on performing actions to improve teaching practice. They have been involved for years in scientific outreach activities and in a number of educational innovation projects, which have developed innovative teaching materials. With the aim of sharing their experience and enhance their performance, the three groups have decided to join forces to become a Network of Educational Innovation whose main projects are described in this communication.

**Keywords**

Educational innovation, collaboration, teaching materials, popular science.

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## 1. Motivation and general guidelines of the Network's activities

The Valencian Network of Educational Innovation in Optics (*Red Valenciana de Innovación Educativa en Óptica*) was established this academic year 2012-13, thanks to a grant for the development of educational innovation from the Vicerrectorado de Cultura e Igualdad at the Universitat de València. It consists of three groups (primarily made up of professors, although they also include research personnel and labratory technicians) from three of the public universities in the Valencian region: the Universitat de València (UVEG), the Universitat Jaume I of Castellón (UJI), and the Universitat Politècnica de València (UPV). Its members have a broad experience in developing programs to improve teaching and, for many years, they have been participating in various science outreach activities and in educational innovation projects, for which they have devised innovative teaching materials. Up to now, the groups under the Valencian Network of Educational Innovation in Optics have developed three important lines of work, which are briefly described below: designing digital simulations and virtual laboratories; designing new experiments for both laboratory sessions and classroom demonstrations; and carrying out scientific dissemination activities.

- *Designing digital simulations and virtual laboratories*. Virtual laboratories are tools designed to provide students with the means to develop their own understanding of the processes they are learning. With this goal in mind, the simulation must give users the possibility of controlling all the variables involved, so that they can analyse their influence on the final outcome. Furthermore, the required visual representations (images, graphs, animation) must be used so that the concepts and underlying relationships are properly assimilated. The groups from the Universitat de València and

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the Universitat Politècnica de València have developed several applications within this line, using *MatLab* and *Easy Java*.

- *Design of laboratory sessions and classroom demonstrations.* Generally speaking, the aim of laboratory sessions is to experiment with physical phenomena, taking measurements, analysing experimental data, and critically evaluating results. Because of this, students who perform satisfactorily the laboratory classes have a considerable advantage for achieving the general course goals, both in terms of procedural objectives, and in terms of attitude and knowledge. In order to accomplish these goals, the methodology applied in the laboratory sessions must be meticulously devised, so that the maximum theory-practice transference is achieved. Keeping in mind all of these points, the three network's groups have taken an interest in designing and setting up new experiments and classroom demonstrations that approach the study of physical phenomena in innovative ways.

- *Science outreach activities.* In order to disseminate the study of Physics and improve the relationship between the university and society at large, it is always desirable to have direct and continuous contact with schools located in the area to fulfil the social responsibility of public institutions of Higher Education. We must emphasise that, in this role, it is necessary to supervise and collaborate with the transition from high school to college and, in our field, to also encourage scientific vocations. This is why the three groups of the network have paid special attention to their relationship with secondary schools, promoting different activities addressed to teachers and students, as well as the general public.

In order take advantage of their expertise in the above areas, the three groups from the Universitat de València, the Universitat Jaume I of Castellón and the Universitat

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Politècnica de València, have joined forces to create a Network of Educational Innovation. The specific goals proposed by the Valencian Network of Educational Innovation in Optics are, first of all, the exchange of teaching experiences and, secondly, the development of specific activities in the members' previous lines of action. To acomplish the first objective, the group leaders from each university have met several times throughout the academic year to begin outlining their joint actions. As for the second goal, it was decided to work together on designing simulations and applets.

The following sections provide a summary of the main activities carried out by each one of the network's groups. The development of all the activities of the three groups was funded by various several for innovative education projects from their respective universities.

## 2. The Universitat de València Group (UVEG)

The Group for Innovative Teaching in Optics (*indopTIC*) at the University of Valencia is made up of professors with extensive experience in the field of optics and a common interest in the development of programs for innovative education. Coordinated by Dr. Amparo Pons Martí, this group was created several years ago, and is recognized as a Consolidated Innovation Group at its university. In fact, it was this group that suggested the creation of the *Valencian Network of Educational Innovation in Optics*, in which Dr. Amparo Pons Martí serves as a general coordinator.

So far, this group has focused on designing and setting up the *Virtual Optics Laboratory* and on proposing new laboratory experiences and classroom demonstrations, although most of its members also participate in different scientific dissemination activities.

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The *Virtual Optics Laboratory* (Pons 2009) is conceived as an educational tool to support the theoretical and practical teaching of Optics, which includes experiments in instrumental and physical optics. Special care has been taken in the design of the virtual environment so that the approach used for the practices is very realistic. The contents are presented sequentially using diagrams, videos, and simulations of the expected results. Questions about the devices are interspersed, for students to check their knowledge about the physical phenomena involved. In developing these virtual experiments, measuring components and self-editing tables of values have also been included to give the students the possibility of facing some of the experimental problems they will find in a real laboratory. The introduction of this kind of items related to the measurement process is an innovative characteristic of this virtual laboratory. As a complementary feature for the virtual experiments, an applet was designed last year for studying the linear polarization of light. The applet allows Malus's Law to be verified by using up to three linear polarizers (see Fig.1).

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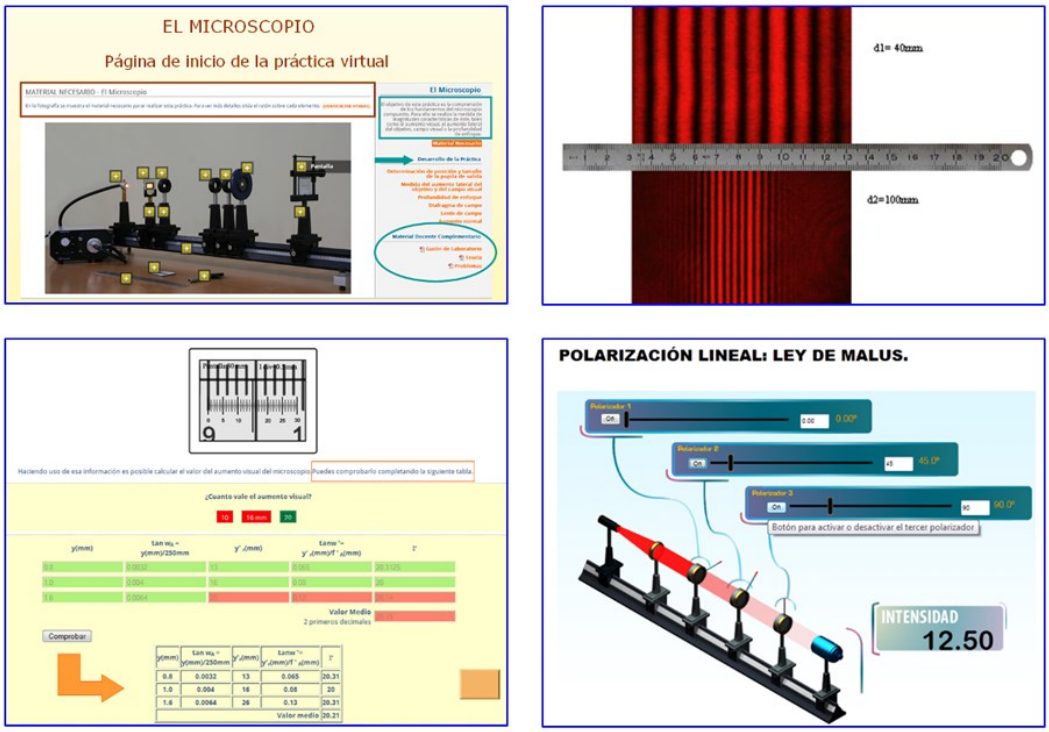


**Figure 1.** Some examples of the Virtual Optics Laboratory

During these years, various laboratory experiments have also been proposed that could be used either as qualitative classroom demonstrations or as laboratory practices. For example, Fig. 2 shows some pictures of two of the proposals carried out: a mechanical model to study the behaviour of a micro-structured optical fibre (Stevenson 2011), and the determination of the average size of the red blood cells in a sample of human blood, based on the measurement of the diffraction pattern generated when the sample is illuminated with a laser beam.

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In the context of the Network, and in collaboration with the group at the Universitat Politècnica de València, work has also been done for developing another kind of virtual laboratory to study the diffraction properties of fractal elements, and for proposing new laboratory experiments, which are described below in Section 4. In all cases, an effort has been made to incorporate innovative components to make them attractive to students.

As for scientific dissemination, most group members regularly participate in all kinds of activities aimed at teachers and secondary-school students. Among these activities, we would like to highlight those related to the Physics Classroom *Experimenta* of the Faculty of Physics, laboratory specially designed for high school students in which training courses for teachers are also taught (http://experimenta.blogs.uv.es/]). Finally, we would like to mention, for its high difussion and social impact, the *Experimenta* Science Fair-Competition (which held its eighth edition last April) in which high school students present to the general public their own experimental projects (Ferrer-Roca 2013).

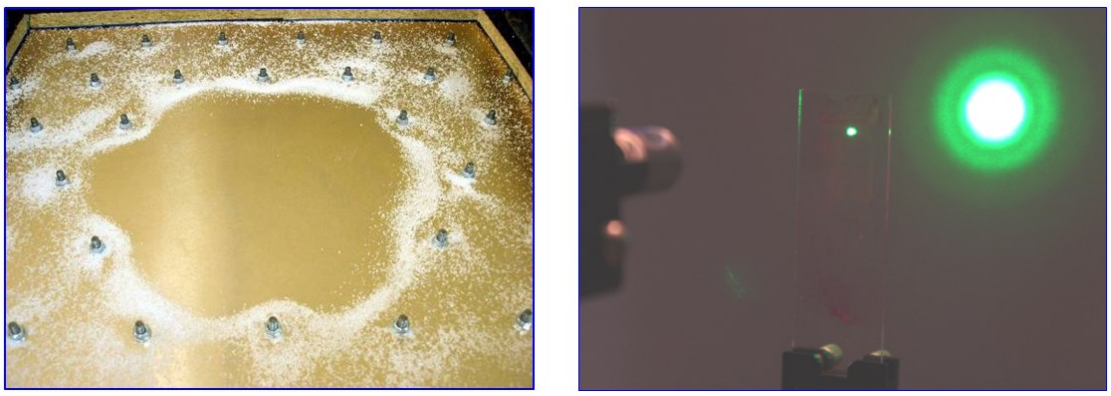

**Figure 2.** Two examples of laboratory experiments

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Also, in collaboration with the group at the Universitat Politècnica de València, they participate in the Summer Science Campus *"Un viaje fantástico con los pies en la Física" -"A fantastic walk through Physics"* (http://www.campuscientificos.es/).

## 3. The Group of the Universitat Jaume I de Castellón

At the *Universittat Jaume I*, in Castellón de la Plana, the team of professors in the field of Optics has been working for years in the areas of innovative education and scientific dissemination, and has strengthened ties with secondary schools. Currently, it is established as an *Educational Innovation Group*, recognized by an internal grant at the university in Castellón under the title *Team for the Teaching and Outreach of Physics,* coordinated by Dr. Mercedes Fernández Alonso. The group members teach in the technological degree programs at the *School of Technology and Experimental Sciences*, which include Degrees in *Industrial Engineering*, *Technical Architecture* and *Design and Development of Video-games*, as well as *Chemistry*.

In the area of educational innovation, the group has carried out different projects pertaining to the development of new university degrees and the process of European harmonization. From the beginning, they have participated in pilot experiences, even before the establishment of the new degrees (Martínez-León 2006, Martínez-León 2008). After the new degrees were put in place, the continued work on educational improvement has centred its efforts on: encouraging student autonomous learning; preparing new educational resources or selecting existing ones; devising and implementing an efficient continuous assessment system; providing support for teaching Physics subjects in English and for the educational coordination of the study of Physics

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in the first years of the new degree programs (Martínez-León 2010, Fernández-Alonso 2011). We should stress that, in the last few years, this educational team has been responsible for the subject Physics II, which is part of the degrees in *Industrial Technology, Mechanical Engineering, Electrical Engineering, Chemical Engineering,* and *Agricultural* and *Environmental Engineering.* This subject is taught in a coordinated way in six different groups made up of students from all these degree programs.

Among their dissemination activities, the group organises the local events for the *Physics Olympiad*, as well as talks and demonstrations that take place in secondary schools or during secondary-school visits to the university campus (such as those included in the *Practica la UJI* program). They participate in the university's *Open Day,* and in the *Science Week* at the different extension centres of university throughout the region of Castellón. The group has also participated in training activities for teachers, such as the courses organized by *CEFIRE* in Castellón, and is teaching classes in the Master in Teaching Secondary School, Vocational Education and Training and Foreign Languages.

Different aspects of Physics are addressed in these outreach activities, although in some demonstrations emphasis is placed on the subject closest to this group's research field: Optics. In fact, they have a series of experiments on light diffraction and interference, polarization, and optical transmission of information, which have been used in science dissemination sessions for all kinds of audiences: undergraduate and high school students, teachers in training, and the general public [Martínez-León 2013). Some of these demonstrations are shown, by way of summary, in the pictures in Fig. 3.

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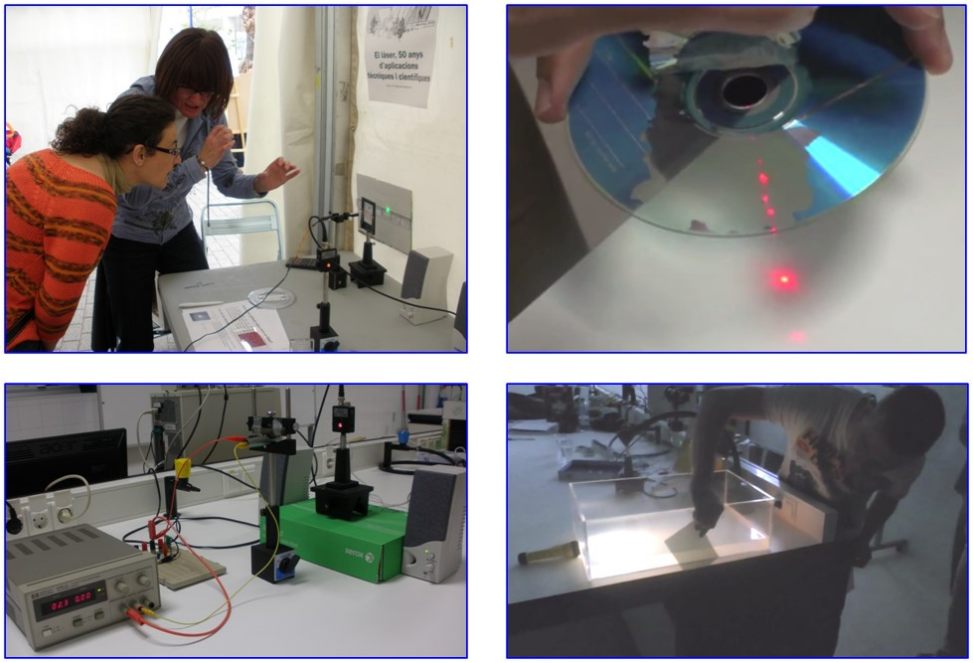

**Figure 3.** Some dissemination activities done by the Group at UJI

For many of these activities the group has relied on the collaboration of their colleagues at the Universitat de València and the Universitat Politècnica de *València*, now integrated in the *Valencian Network of Educational Innovation in Optics*. Together, they have begun to devise new educational resources that take advantage of information technologies to promote the students' autonomous learning.

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## 4. The Universitat Politècnica de València Group

The third team of the *Valencian Network of Educational Innovation in Optics* is constituted by professors from the departments of Physics and Applied Mathematics at the Universitat Politècnica de València. This multidisciplinary team, coordinated by Dr. Juan A. Monsoriu, has extensive experience in mathematical modelisation through virtual laboratories, used as an aid for the teaching-learning process. For several years, they have been developing digital simulations (using MatLab and Easy Java) of physical processes, such as the movement of blocks and wheels, oscillations, waves (Giménez 2009), etc. Within the specific context of the *Network*, they have developed a virtual laboratory for the mathematical modelisation of the diffraction properties of fractal gratings (Giménez 2011) (see Fig.4) which, in turn, is complemented with real experiments (Monsoriu 2011). They are currently working on the application of these diffraction gratings to other aperiodic sequences (Fibonacci, Thue-Morse, etc.).

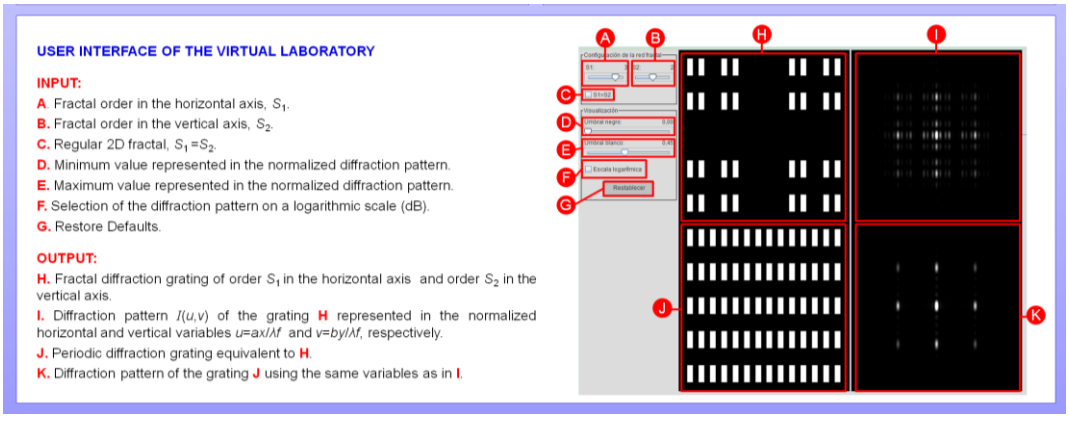


**Figure 4.** Virtual Laboratory DIFRACT.

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In addition to the virtual laboratories, in recent years the group has also worked on the development of new, highly innovative laboratory experiences. With the aim of enhancing the theory-practice transference, they have made a point of introducing innovative elements in their laboratory experiments which will arouse the students' interest in carrying out the practice, such as can be, for example, the video analysis of physical phenomena (Monsoriu 2005) or taking measurements with the accelerometer of a Smartphone (Castro-Palacio 2013).

In collaboration with the group at the Universitat de València, they have proposed some of these innovative experiments, such as determining the spatial resolution of a LCD or CCD through diffraction (Barreiro 2012, Barreiro 2014). Figure 5 shows some images of these laboratory experiences. Currently, the *Valencian Network of Innovative Education* is studying the possibility of using the built-in lux meter of a Smartphone in different Physics experiments.

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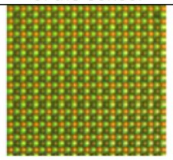
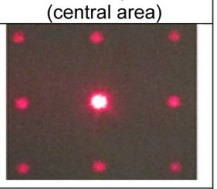
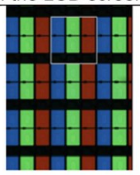
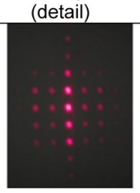
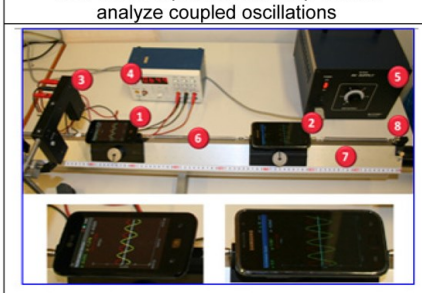
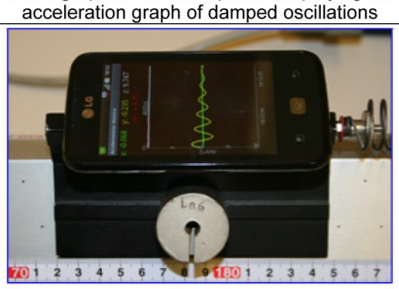
| **Diffracting element: CCD Sensor from the photographic Camera Canon Ixus 80 IS** | | |
|---|---|---|
| General view of the camera and its sensor | Microscope image (40x) of the sensor | Diffraction pattern (central area) |
|  |  |  |
| Pixel size: $d_x$ (μm) x $d_y$ (μm) | 3,33 μm x 3,33 μm | 3,3 μm x 3,3 μm |
| **Diffracting element: LCD screen from the HTC smartphone** | | |
| General view of the smartphone and its display | Microscope image (40x) of the LCD screen | Diffraction pattern (detail) |
|  |  |  |
| Pixel size: $d_x$ (μm) x $d_y$ (μm) | 175,23 μm x 175,23 μm | 173,8 μm x 174,4 μm |
| **Using a mobile phone acceleration sensor in physics experiments on oscillations** | | |
| View of the experimental setup used to analyze coupled oscillations | Photograph of the smartphone displaying an acceleration graph of damped oscillations | |
|  |  | |

**Figure 5.** A few innovative proposals for laboratory experiments

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