Spreading Optics in the primary school

Ana Gargallo¹, Ana I. Gómez-Varela, Héctor Gómez-Nuñez, Tamara Delgado, Citlalli Almaguer, Ferran Cambronero, Ángel García-Sánchez, David Pallarés, María Aymerich, Ángel L. Aragón and María T. Flores-Arias

Departamento de Física Aplicada (Área de Óptica), Universidade de Santiago de Compostela, Facultade de Óptica e Optometría (Campus Vida) 15782 Santiago de Compostela (SPAIN)

¹E-mail: usc.osa.sc@gmail.com

Abstract. The USC-OSA is a student chapter located at the University of Santiago de Compostela (Spain) whose objective is to bring optics and photonics knowledge closer to general public. In order to arouse kids’ interest in Optics we developed an activity called Funny Light. This activity consisted on a visit of some USC-OSA members to a several local primary schools where we organized several optics experiments. In this work we present the optics demonstrations and the reaction of the 6 years-old students. The activities with greater acceptance include an explanation of light properties as polarization, refraction or reflection, and the workshop where they learnt how to build their own kaleidoscope and made a chromatic disk. Besides, they also participated in a demonstration and explanation of color properties and some optical illusions. We think that this activity has several benefits including spreading Optics through children meanwhile they have fun and experiment science in real life, as well as helping teachers to explain some complex properties and Physics phenomena of light. Given the broad acceptance of this activity, we are intending to make it a routine event of our student chapter repeating it every year.

1. Introduction

International scientific societies focused in Optics and Photonics promote the association of students in universities worldwide in order to involve them in the task of spreading the Optics knowledge into the community. These students groups are called Student Chapters or Student Clubs and are formed by students of different careers related to Optics. They receive funding and networking from an international organization with the goal of increasing the interest in Optics in pre-college students and provide at the same time professional development of its members.

The USC-OSA student chapter was founded in 2013 at the University of Santiago de Compostela and is supported by the Optical Society of America (OSA); this is an organization whose mission is to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide since 1916. In 2002 the OSA established a non-profit organization for keeping with that mission, the OSA Foundation, which supports programs that advance youth science education, enriches Optics and Photonics education in developing nations, provides professional development resources to college-level students and recognizes technical and business excellence. The OSA Foundation funds several grant programs, competitions and events that benefit the Student Chapters and their members [1].
One of the goals of the USC-OSA student chapter is to arouse kids’ interest in Optics. In order to attain this objective we developed an activity called Funny Light, which was carried out at some primary schools in Santiago. This activity consisted on a visit of some USC-OSA members to local primary schools where we organized several optics experiments with children. In this work we present the simple optics demonstrations and the reaction of the 6 years-old students. The activities were grouped in two blocks; the first included demonstrations made by chapter’s students and the second block consisted in some workshops where children could make up optics handicrafts. Those with greater acceptance include an explanation of light properties as polarization, refraction or reflection, and the workshop where they learnt how to build their own kaleidoscope to understand reflections of light and made a chromatic disk to feel how white light is compound of colors. Besides, they also participated in a demonstration and explanation of color properties and some optical illusions.

2. Optics experiments for children included in Funny Light activity
In this section we present the activities carried out in three primary schools located in Santiago de Compostela with children of 1st and 2nd course.

We separated pupils in two groups of 25-30 children. One of the groups realized the first activity called Let’s play with light, which consisted on Optics demonstrations of refraction, reflection, polarization, etc, meanwhile the other group built the kaleidoscope and the chromatic disk.

In the global activity, around 200 kids between ages 6 and 7 of different schools were involved. All the activities were developed in a 4 hours morning school journey in separate days for each school.

2.1 Let’s play with light.
In this activity, we usually started with a presentation and then the children were separated in small groups of 6 or 7 people and distributed in 4 stands where an USC-OSA member made a demonstration. Each group spent 15 minutes in each stand and then they changed their location with their colleagues in order to participate in all of the experiments. Let’s play with light consisted on the following activities to show how the light works:

2.1.1. Visual perception. We started with a presentation explaining with funny cartoons that all we see is light. With the aid of the Optics Suitcase, provided by OSA, the children recognized the colors in white light with a little lantern and a diffractive grating (figure 1). Some curious aspects about human vision as binocularity, contrast and sharp perception or color vision were demonstrated with optical illusions cards. Optical illusions or visual illusions can induce images that are different from the objects that create them. For example, some of the illusions can show the ability to see in three dimensions even though the image in the retina is only two-dimensional. Others affect the contrast of a homogeneous object, appearing darker against a black field compared to a white field.

We made a selection of different cards to explain contrast and sharp perception, binocularity, motion perception or color vision.
2.1.2. **Light painting.** Light painting is a photographic technique in which exposures are made by moving a hand-held light source or by moving the camera. With a reflex camera Canon EOS 7D and led lanterns we took pictures using this technique. In groups of 5, each child draw a letter to form a five-letter word while the other children had to guess what they wrote (figure 2).

2.1.3. **Color experiment.** We demonstrated the color composition of white light by creating a rainbow in the classroom with the aid of a prism and a white light source and explaining children how the raindrops behave as a prism.

In order to make children learn about primary and secondary colors we used an old overhead projector, three movable mirrors and a plate with three filters (green, red and blue). We placed a stand with the three movable mirrors close to the projector and a plate with the three filters (green, red and blue) over the light source. This set up allowed us to project color circles on a screen or a white wall and mix them in pairs by moving the mirrors; at the end, we mixed up the three color circles to obtain white light. Moreover, the children could make colored shadows with their hands (Figure 3). We also used a template with a part of a house in each color and the complete figure was formed when the three colors were mixed.
2.1.4. **Polarization**. This property of the light is very difficult to understand for children and also for adults. We designed an experiment to show how polarization is a useful property in life. We used an overhead projector with a polarized filter in the light source, some polarized filters and different objects made of transparent plastic material as a rule, toothbrush or cookies envelope (Figure 4). The Optics Suitcase includes individual packs of polarizer filters and plastic materials and each kid could experiment by itself this characteristic of light.

![Figure 3](image1.png)

**Figure 3.** Color experiment. In (a) we can see the projection of the three primary colors in a white wall and the secondary color as a result of the mixing in pairs. In (b) there is a picture of colored shadows.

2.1.5. **Refraction and reflection demonstrations**. We explained refraction with two glasses and a pencil. One of the glasses was filled with water and the other with oil, thus children could see how the pencil seems to break and twist more in oil than in water because of their different refraction indexes. Another experiment was carried out with a glass over a coin; the coin looks to disappear when the glass is filled with water because of the change in the angle of the light.

With a special box made by two opposite concave mirrors and an aperture in upper mirror we generated a real image of a well-known physical object (Mirage® PARABOLIC MIRROR HOLOGRAM MAKER). The object is placed in the center of the bottom concave mirror and a real image instantly projects up through the aperture, appearing to the viewer as a truly solid object. Any small objects can be used e.g. a coin, marble, sweets, etc. This is an ideal way to demonstrate and teach the concept of real images [2].

![Figure 4](image2.png)

**Figure 4.** An USC-OSA member showing to children the change in color of a projector with a polarized filter.
2.1.6. Optical fiber simulation with water. Based on Colladon, Babinet and Tyndall [3] experiments, we built a waveguide device with a bottle of water, a laser and a bucket. We made a hole in a lateral of the bottle close to the bottom; the bottle was filled with water and illuminated through from the other side of the bottle with a red laser beam. Water stream was collected in the bucket. Kids could see light being guided through the water and reaching the bottom of the bucket, instead of propagating in a straight line to the wall. Water plays as a waveguide in this simple experiment and explains the total reflection of the light.

2.2. Optics handicrafts
This part of the event involved fifteen 6-years old children from the 1st course of primary school. It took place in a manual arts classroom.

2.2.1. Kaleidoscope construction. Brewster invented the kaleidoscope in 1816 [4] and this device still leaves an impression on young children. We organized a workshop in the school where every child built his own kaleidoscope. We used three mirrors arranged in an equilateral triangle, taking into account the age of the children, we substituted crystal mirrors for plastic plates covered with reflective paper. The plates were situated inside a toilet paper tube; one transparent plastic circle was located in one side of the cylinder; over it, the children put some glass beads of different colors and finally covered all with a piece of one translucent plastic bag. The other side of the tube was covered up with a ring made of cardboard. The outside was decorated with color paper and figures (Figure 5). We had to help some of them with cutting and sticking tasks because of the young age or child ability. USC-OSA members could explain reflection property of the light with this enjoyable workshop.

![Figure 5: The kaleidoscope workshop. The finished kaleidoscopes are shown in (a); in (b) children are looking through them.](image)

2.2.2. Chromatic disk. In 19th century the use of chromatic disk mixture was the only mean for defining color stimuli and matching. Nowadays it is only a curiosity but could help in children comprehension of colors [5]. We prepared a template in order that the kids could paint it following a pattern, then they cut the circle and stuck it in a pencil to allow them to spin the disk around and observe the color mixture (Figure 6).
3. Discussion
It is important the knowledge of basic experiments and techniques for spreading Optics and Photonics in schools and high schools, but it is also important the people who develop these activities into the community and bring them closer to teachers and students. We think that an organized group works better than an individual person and takes less effort for its members, so we created the USC-OSA student chapter.

Physics concepts of light properties are often difficult for kids, also for adults who are not familiarized with that field. With simple experiments we could catch the attention of the youngest schoolchildren. We are conscious that they did not understand in deep some of the light properties presented, but they discovered some aspects of Optics that aroused their interest. We want to broaden the activity into older children and pre-university students in order to make visible the uses of Optics and Photonics in the daily life.

Concerning the first part of the event, the children enjoyed a lot with all the experiments and show an active participation. In particular, the Polarization demonstration was very welcome, in contrast with our expectations because it is a complex concept of Optics. The Optics handicrafts activity was developed only in one course because it required us to work in small groups with the kids in order to help in the task of cutting, assembling pieces, sticking, etc.

4. Conclusions
We think that this activity has several benefits including spreading Optics to children meanwhile they have fun and experiment science in real life, as well as helping teachers to explain some complex properties and Physics phenomenon of light. Given the broad acceptance of this activity, we are intending to make it a routine event of our student chapter repeating it every year.

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Figure 6. In this figure a child is trying out the color mixture with a chromatic disk in a not moving (a) and moving state (b).