Learning optics at basic schools by experimentation

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ABSTRACT

In our emerging Society of Information, Light and Optics have a crucial importance not only in Science and Technology but also in the widest range of aspects of our every day life. It is of utmost importance to introduce our young students to the basics of optics and photonics as soon as possible. Inscribed on the Ciência Viva program, launched in 1996 by the Portuguese Ministry of Science and Technology, I proposed and coordinated six different projects on the theme of elementary optics teaching. All the projects toke place in schools of different types and were developed by above forty physics, chemistry, computer sciences and electronics teachers. Well over one thousand students participated directly in the projects but many more were, and still are involved in several activities organized by the teachers and students themselves open to all school and the community. All projects had the same object and goals. However they correspond to different ways of meeting the objectives upon the type of school and students involved.

Keywords: Optics, Science education, School, Hands-on experiments

1. BACKGROUND

The main goal, the work of the physicist is to discover to understand and to explain the physical world.

To observe, to see critically, is the first fundamental step in this process. The student must not only to understand this deeply, as they must to be taught to see, to observe. This should be the first concern of a physics/science teacher.

We may even argue about the interest of explaining, transmitting the concepts if the student is not able to "see" the problems, the situations and is unable to distinguish/discriminate the processes, the problems involved that need to be solved or explained in order for the situations to be understood. It is definitely of utmost importance to early teach the students to observe but also to raise questions, to perform critical analysis, to build new situations and scenarios.

In order to captivate the students attention and interest on physics (and science and technology in general) it is common practice among the most concerned teachers to make the presentation or demonstration of some experiments, as spectacular as possible. A high degree of sophistication is often sought in order to increase the impact among the generally alienated students. The problem is that it is more and more difficult to find new

situations that could surpass the ones all and every student already saw repeatedly on TV or cinema. Furthermore they tend to accept as enough the ideas/explanations (usually inaccurate and often even wrong and misleading) they receive in such a way. Moreover they do get them selves definitely bored when attempts are made to discuss and explain those subjects. The major problem with this process is that the "information" is *received* fast and in an extremely passive way. They see, they ear but never critically. And in that way no meaningful knowledge can ever be attained!

So,... what to do? Lets turn into the basics, to "simple" things, every day situations, simple old fashion apparatus. And, above all, lets give time (we should never forget teaching takes time and learning takes much more!) the students to see, to discuss, to play with, to enjoy, to have fun, to feel the trill of discovery, to wonder them selves with the world of physics... Nice words!... In reality... it do pays the effort!

Increasing students' specific knowledge is important. But above all science demands work, responsibility and ***method***. It is precisely this the most important thing the science teaching should give to the students.

Hands on, experimental work is surely be the best way to achieve those goals. Furthermore in classic lectures students have an attention span less then 15 minutes. The introduction of, even if small, practical hands on activities or some practical problems to be discussed in class, do allow a much more effective extensive use of the class time.

We can not expect that all of our students will become scientists or fellows truly interested on these subjects, but it is our "obligation" to try to make that number the higher the possible[1-7].

2. INTRODUCTION

The generic objective of the "Ciência Viva" (*"Science Alive"*) program[8] created in 1996 by the Portuguese Ministry of Science and Technology was to improve and enlarge the use of experimentation on teaching science classes in basic and secondary schools.

Our specific objectives arose from the huge deficiencies in the knowledge of the even very basic concepts of optics I first noticed on my classes of geometrical optics at the undergraduate course of Applied Optics (optics branch) at the University of Minho. More then one quarter of the students stated that they have not ear about optics ever in classroom (for instance in the 8th grade the optics subject is optional and most frequently not taught at all) before entering the university! Only a few students have shown an acceptable understanding of the meaning of index of refraction. A higher number of students recognized the lens maker formulae. But... could not solve a simple minor problem with it, nor could even explain what they think the terms *image* and *object* are or mean!

Our specific goal was thus to complement the formation of the basic and secondary schools' students in the field of Elementary Optics.

My objectives found a good receptivity among several teachers of five Minho's basic or secondary schools EB, 2/3S de Celorico de Basto (EBSCB), Fermentões (EBF), Alberto Sampaio (ESAS), Vila Verde (ESVV) and CENATEX. All schools of different type operating in different contexts. The ESAS is an average size secondary school located in the center of the town of Braga the District capital of Minho. The ESVV is a basic and secondary of a small fast growing town in the suburbs of Braga. Settled in the outskirts of a large industrial town the activities on the basic school of Fermentões are strongly conditioned by a rather difficult social environment. On the other hand the EBSCB in a countryside environment have very nice operation conditions with teachers and students extremely cooperative and enthusiastic. Finally the secondary school CENATEX is a professional school in technological subjects.

In the overall more the 1200 were directly involved ages from 12 to 18 years coordinated by around forty school teachers in a large number of different types of activities.

3. *A BRIEF OVERVIEW OF THE EXPERIMENTAL PROJECTS AND ITS RESULTS*

The two first projects (ESVV and ESAS) back in 1997/98 have established the basic ideas and strategies on teaching the basics of optics to this kind of students.

A small set of hands on simple experiments (however with an increasing complexity) was prepared together with a small activities' guide[3-6]. A permanent appeal is made to an active critical posture. All of the sessions' evolution relies essentially on the observation. The students should see, discuss and get their own conclusions and whenever possible to establish what to do next. They are encouraged to step out of the guide's proposals and follow their one paths to reach the goals. Time was rather short and the students were not used to this kind of action. Thus all the actions were not fully accomplished. This was definitely not considered a major drawback. Each student has his own pace and we should also understand that. Rushing things it is not a good strategy at all.

The students begin *looking* and discussing different sources of light from the sun to sodium fluorescein. Light dispersion with Newton prisms was next. A short analysis of the human visual system was performed. The color vision and color matching were then introduced. Definitely enchanted students performed several simple experiments. Some optical illusions have been observed and discussed. Next they entered the domain of the basics of geometrical optics. Simple ray tracing experiments were done. The mirrors and lenses were introduced. The microscope and the telescope become rather popular! Other topics like spectroscopy, optical sensors, diffraction concept, holography and fiber optics were also include.

Along the years the material, guides and experiments involved were improved and enlarged trying to establish bridges to other fields of knowledge in an interdisciplinary way. Not only the very basics of light and optics are object of our projects (EBSCB and EBF). We also included more advanced approaches to topics like optical sensors, fiber optics and telecommunications (CENATEX) in interdisciplinary ways involving not only physics teachers and students but also electronics or chemistry teachers and students in a project were the focus is on the spectroscopy and its applications (EBSCB).

The very positive way the project evolved on the classroom's experimental activities was confirmed by the assessment of the students' *knowledge* improvement on these matters. But, above all, the interest of this kind of actions was marked by the students opinion expressed on voluntary surveys the students filled by the end of the action. 98% of the students was very pleased with the action and expressed their desire of seeing it continued. A important majority stressed the importance of hands on experimental work on learning physics. But perhaps more important its that the students soon began organizing their own activities. For instance every Wednesday afternoon (even on holidays) the physics lab of the EBSCB is open to the students that organize autonomously and work almost entirely alone, on themselves.

Even with younger students[8] from pre-school or elementary (5 to 8 years old) this kind of action have a striking positive effect. The basics of some subjects are easily understood: addition of colors (often older students take longer to understand the process because they are used to the subtractive ink's color mixing), reflection of light and internal total reflection (a piece of sweet flavored jelly may act as an *wonderful*... light guide!), refractive bending of light (the coin in the *bottom* of a plastic cup; a trip to a rivers' shore may become an highly productive and pleasant experience!).

Confirming what I said above in the introduction even the younger children insistently request to see and play (literally!…) with lasers. Constant references are made to TV films or cartoons. Fiber optics are also mentioned and when in use they become very popular. Not only the students see that light can go from one side of

the fiber to the other even if highly bender as they also realize the fiber can be used to *see* objects in the other end away.

4. CONCLUSION

Perhaps more important than knowing concepts or theories is to know how to get them. It is necessary to teach and predispose the students to observe, to think, to reason, to analyze critically and interactively problems and situations. More important then the final concepts, is to know, to feel, to interiorize the paths or processes of, or to, understand them.

Once more it was clearly proven that the pursuit of experimental hands-on work by the students on or off the classroom its a powerful way to helps us science teachers to reach our basic goals.

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