Light, Optics, Action . . . Enhancing Science's Teachers Knowledge on Modern Optics Applications

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Abstract— **To enhance the knowledge of science's teachers (elementary and secondary level schools) in topics of modern optics, a short course with laboratory activities is organized. Covered topics include a review of modern physics applied to optical phenomena, the use of optics in modern living apparatus, optical communications and optical techniques for the chemical analysis of materials.**

Keywords— **Optics Education, Education**

I. Introduction

Brazilian students face modern optics in a very restricted vision during elementary (ages 7-14) and secondary (ages 15-17) school education. Most of the optics taught during those years are the concepts of geometrical optics (lenses, rays, . . .) with a few contents on ondulatory optics (diffraction, interference, . . .). Apart from the deficiency of optics contents in the curriculum, another contribution to that lack of modern optics is the preparation of Science's teachers. Presently most science's teachers have a degree other than Physics (Mathematics, Chemistry, Biology, . . .) or they have a reduced degree in Physics (only three years course, rather than the standard four year one). The reduced degree has less lecture hours devoted to modern physics (quantum mechanics, atomic and molecular physics, quantum electrodynamics), not only because the course is shortened, but also because pedagogic lectures are enhanced. As a consequence, people graduated for science teaching in elementary and secondary schools lacks the necessary preparation to understand the basic physical phenomena responsible for most of modern optical devices and they avoid such themes when teaching.

The restricted approach in science teaching during secondary school (most adverse but not restricted to Physics) also contributes to induce students to apply most for universitary degrees not related to science (particulary engineering) but with majors in social sciences. As a consequence, the number and quality of students enrolling for scientific majors during their universitary degree is steadly decreasing. To reverse such situation, a national program[1] was launched a few years ago, aimed to re-design engineering curricula at Brazilian Universities to fit a modern view of engineering as an applied science (REENGE). A secondary objective of that program is to widespread the notion of science to students and teachers of the lower levels of education, in order to attract more candidates to engineering degrees. Some actions in the later direction are open periods for secondary students and teachers to join a research group, upgrading courses, open labs day, . . .

Our group has been deeply envolved in the actions of the above mentioned program, with aims in a better understanding of optics as a fundamental tool in modern engineering, particulary but not restricted to materials, electronics and telecommunications[2], [3]. Activities carried by the group are extensions of previous work done with colleagues in Brazil and Colombia to enhance the teaching of optical communications to electrical engineers[4], [5]. We had also a few previous experiences in proposing and developing teaching aids for secondary schools teachers in optical matters, using acessible basic materials[6], [7]. The later works obtained great dissemination among school teachers, through "workshops" held periodically in the past 6 years around all the country and including a few meetings in Argentina.

As a side work of our group in the above mentioned REENGE program, we decided to offer a short course for science's teachers from elementary and secondary schools. The contents covers a subset of optical themes, choosen in order to present how optics is used in some research labs and in consumer goods.

II. Description

In order to include experimental activities in the course, we decided to restrict the program to a few topics related to research carried on at our Institute. We also have some constraints in mantaining the course short and off term, in order to do not disturb normal classes of our engineering degrees. A second factor to keep course short was due to it's offer during school hollidays, as a longer one might be discarded by teachers with plans to travel during their vacations.

The choosen themes for the course lectures were:

- A review on optics and modern physics
  - Waves, wave nature of optics, diffraction, dispersion and interference.
  - Energy levels and optical transitions. Absorption. Emission.
- Lasers, applications in industry and research
  - Stimulated emission. Laser principles. Optical characteristics of lasers.
  - Laser types. Applications of lasers in the industry, research and medicine.
- Chemical analysis of materials using optical techniques
  - Spectrophotometry. Qualitative and quantitative analysis.

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– Kinetics reactions measured by optical means. Optics in cromatography.

• Optical Communications

– Fiber Optics. Light propagation in optical fibers.

– Optical communication systems. Optical amplifiers.

– Fiber optics based instrumentation.

While the experimental part of the course was based on four workshops:

– Lasers: holography and interference measurements

– Chemical photometry and materials analysis.

– Optical communications: Television link in open space and in optical fibers.

– Optics in the classroom: how to build a diffraction grating and a spectroscope.

During lectures, we tried to bring real life examples for the audience, like, eg., liquid crystal based displays, CD-ROM & audio CD's readers, spectra of fluorescent and high pressure gas lamps, fluorescent authetication of banknotes, white light holograms, ... For the experimental workshops, attention was paid in order to bring to the participants experiments with a real feeling of how optics is used in the research lab. The last topic of the experimental work was devoted to induce teachers to prepare their own materials, in order to supply laboratory deficiency in their schools.

Lectures were condensed in one week, using a 4 hour daily schedule. For the experimental part, participants were splited in several small groups, each one attending an extra 4 hours period in each laboratory. Due to logistics, the later was carried along several weeks, using only one day per week. The exception was the topic "Optics in the classroom" which could be done with all participants together.

III. Evaluation

We decided to offer the course initially to teachers of public schools in our city. The title (Light, Optics, Action ! ...) was choosen in order to attract attention. It was a complete surprise to us as it called attention, so that the first class was closed earlier, limited only by the classroom size (24 attendants). Participants were asked a low nominal fee, only to cover the costs of some reprinted material.

The participants were almost equally divided between Physics and Chemistry teachers in secondary school and Science teachers (7^{th} & 8^{th} grades) at elementary school, with the first group being slightly large.

Attendance to lectures was quite high and participation, with questions or comments in large number and consistent. However, some severe misunderstanding of basic concepts in optics and physics were observed, as we expected. Lecturers tried to solve all doubts and questions and they also tried to bring real life experience to explain and clarify such concepts to the audience. Special attention was given to bring optics insight to participants when the question was related to consumer appliance.

Participation in the laboratory sessions was not so high, probably as the extension of the course to other weeks, overlaping with normal school term, caused interference with professional duties of attendants. This reason can be deduced from the session "Optics in the classroom" that, also due to logistics, was held just as the first experimental session after conclusion of the lectures. Attendance to this session was almost complete and participants have enjoyed its activities. Even if attendance in other sessions was not complete, the participants in each one had deep interest to recognize the basics principles taught during lectures when in use in the laboratory. Some experiments, like video transmission by a laser beam in the air or through optical fibers called high attention from the participants. We profited from this experiment also to transmit the video signal of OSA's "Ligth as a Modern Tool", commented in Portuguese by one of the lecturers.

To avoid the reduction of audience in the experimental sessions, we plan to join the experimental part in a second continuous week.

IV. Final Remarks

In our opinion the result of the proposed course is considered very good and we plan to offer it periodically during school vacations as a training activity for school science's teachers.

Acknowledgments

This work is partially supported by CAPES, CNPq and FINEP (Brazil). We also acknowledge the NUCCE (CEFET-PR) staff for their help with the press release and administrative tasks related to the course.

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