Physics teachers visiting the new synchrotron light source

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Abstract

This work aims to present the report of an experience and the description of a technical visit carried out in one day by 60 high school science teachers to a complex of laboratories in the largest scientific infrastructure in Brazil. This visit was part of a scientific dissemination strategy by one of the authors, in a survey in the laboratories of the National Center for Research in Energy and Materials for a complementary training of teachers.

Keywords: Synchrotron light, high school teachers, physics education, physics teaching.

Resumen

Este trabajo tiene como objetivo presentar el relato de una experiencia y la descripción de una visita técnica realizada en un día por 60 profesores de ciencias de secundaria a un complejo de laboratorios en la mayor infraestructura científica de Brasil. Esta visita fue parte de una estrategia de divulgación científica de uno de los autores, en una encuesta en los laboratorios del Centro Nacional de Investigaciones en Energía y Materiales para una formación complementaria de docentes.

Palabras clave: Luz sincrotrón, profesores de secundaria, educación física, enseñanza de la física.

I. INTRODUCTION

An excellent way to observe nature is through electromagnetic radiation. This is easy to understand when a science teacher introduces the laws of optics, and explains how light propagates and how we see things. But human vision is limited, and to overcome these limits, we need to use instruments that see parts of electromagnetic radiation that are not identified by the human eye.

An example of these instruments, which serve to see what is invisible to the human eye, are synchrotron light sources, which generate different types of electromagnetic radiation, and which are produced in machines that accelerate particles. This type of radiation has a wide spectrum of energy and is generated in particle accelerators by relativistic electrons bent by magnetic field. Due to its variable wavelength, it is used in research to detect waves in the infrared to x-ray lengths [1, 2]. This light is able to detect nanometric objects, in addition to having great intensity and high brightness, which are very important properties for obtaining high resolution images [2, 3].

Although this type of research is commonly disseminated in universities and research centers, this information rarely reaches schools. Normally, high school teachers, when interested and motivated, are able to carry out the so-called didactic transposition, which is the need to adapt scientific knowledge for pedagogical and educational purposes, in order to make connections between different knowledge.

Understanding the importance of bringing high and middle school teachers closer to research centers, a technical visit was organized by sixty physics, chemistry and biology teachers from the city of Rio de Janeiro, to the National Center for Research in Energy and Materials (CNPEM), in Campinas. CNPEM is the largest technological infrastructure in Brazil, and has four large national laboratories: I) the National Synchrotron Light Laboratory (LNLS), which operated until 2020 the only synchrotron light source in Latin America, called UVX, and from 2022 operates the new fourth generation Brazilian accelerator, called Sirius, analyzing the most diverse types of organic and inorganic materials; II) the National Biosciences Laboratory (LNBio), which develops research in frontier areas of bioscience, with a focus on biotechnology and pharmaceuticals, III) the National Biorenewables Laboratory (LNBR), which researches biotechnological solutions for the sustainable development of advanced biofuels, biochemicals and biomaterials, using Brazilian biomass and biodiversity; IV) the National Nanotechnology Laboratory (LNNano), which carries out research with advanced materials, with great economic potential for the country [4].

Several programs have successfully introduced high-school teachers and students to the physics of big accelerator

facilities in order to achieve scientific inquiry in a safe and fun way [5, 6, 7].

This private trip, which covered 500 kilometers by bus, was organized by one of the authors of this article, at the time a PhD candidate, whose focus was a project at CNPEM, which facilitated contact with researchers for the adaptation of a road map

II. TOUR DESCRIPTION

To be as assertive as possible in achieving the objective of providing current high school science teachers with access to high quality scientific laboratories and meetings with professional researchers, a selected group of 60 professors was invited to visit the CNPEM facilities. They offered to participate in the visit, which was an individual commitment, and most opted for a 14-hour round trip in common and exclusive transport (bus), reinforcing their spontaneous individual engagement to strengthen personal and professional goals, plans and challenges during the time together, even if it was while traveling.

Considering their universe of students, these teachers managed, on the other hand, to disseminate this knowledge to thousands of their high school students.

The most significant factors that guided the invitations were that these teachers should be working effectively in high school science classes, and most of them resident in the city of Rio de Janeiro, their professional activities should be carried out in public or private schools, and they should be teaching the natural sciences currently available in the Brazilian education system: Physics, Chemistry and Biology. The technical visit was organized only with the objective of taking physics teachers, but some chemistry and biology teachers were interested, and therefore, some vacancies were added for other areas.

The visit was planned to offer a structured and meaningful view of the scientific research in progress and the technological achievements available in four National Laboratories installed at CNPEM: National Synchrotron Light Laboratory (LNLS), National Biosciences Laboratory (LNBio), National Nanotechnology Laboratory do Brasil (LNNano) and the National Biorenewables Laboratory (LNBR).

Every science teacher can benefit from having access to topic-specific examples and applications, as well as an integrated, multidisciplinary approach to support their future curriculum revisions.

The CNPEM team provided valuable presentations and tools that helped these teachers rethink their individual lesson plans, taking advantage of deeper learning opportunities for their students, and including their school communities in a real science environment.

Understanding the kind of impact that this visit could have on the scientific knowledge of each professor, and aware of the potential for the development of a strong professional network among them during this common experience, the visits to each National Laboratory were organized in smaller groups of 12 professors, each being guided by the local team to explore one National Lab at a time, and then alternating positions with other groups to complete the four labs. These visits took a full working day, posing the extra challenge of scheduling a common schedule among so many different teachers, schools and labs, which made for a successful one-day visit.

To achieve the aforementioned objectives, these teachers were grouped so that diversity could be guaranteed. Individuals were encouraged to share their own knowledge related to the topics presented, and incentives were given to exchange suggestions for new teaching approaches. To be more specific, each group was organized to ensure professionals with different years of teaching experience, from different education systems (private or public), of different ages, genders and social backgrounds.

The organizers and researchers of the four laboratories of CNPEM, understanding this objective, prepared extensive presentations to support each group and provided space for questioning and exchange of experiences.

III. EXECUTION OF THE VISIT

The big challenge of this trip was to organize a visit of 60 high school teachers (50 physics, 7 chemistry and 3 biology) in 1 day to get to know the four national laboratories. At the time of the technical visit, the LNLS had two large laboratories, UVX and SIRIUS, which are respectively the old and new Brazilian synchrotron light sources.

Five researchers were responsible for presenting the UVX, LNNano, LNBio, LNBr and Sirius, and the group was divided into 5 groups of 12 teachers. Each group was identified with a letter: A, B, C, D and E. The tour schedule was as follows:

TABLEI. Schedule.

	UVX	LNNano	LNBio	LNBr	Sirius
08:30 AM	Opening Speech				
10:00 AM	A	B	C	D	E
11:00 AM	E	A	B	C	D
12:00 PM	D	E	A	B	C
01:00 PM	Lunch				
02:30 PM	C	D	E	A	B
03:30 PM	B	C	D	E	A
04:30 PM	Closing lecture				
05:00 PM	Finalization				

The five researchers from the laboratories planned to present the concepts present in each laboratory that would dialogue with the concepts studied in high school, so that the visiting professors could make the connections. Materials and access links to institutional videos were made available, so that each teacher could return to their educational institutions and be able to make presentations about the visit.

Figure 1. Group A.

Figure 2. Group B.

Figure 3. Group C.

Figure 4. Group D.

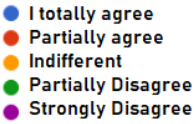
Figure 5. Group E.

Figure 6. All 60 teachers in the closing lecture.

IV. DISCUSSION OF RESULTS

At the end of this immersion of the 60 teachers in a research environment, an opinion poll was carried out on the main themes of each laboratory and that was connected with electromagnetic radiation, so that there was a communication with the school contents [8, 9].

Some questions were asked, and we selected four that dialogue with the construction of the concept and with the future action that the teacher can perform after the visit to the laboratory complex. For each question asked, teachers should answer among the options:



Questions:

1) In your university education as a teacher, were the issues related to radiation worked and related to the application in basic education?

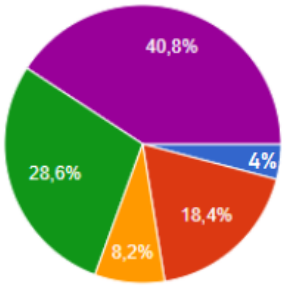


Figure 7. Answers to the first question.

2) Can your high school students easily understand the difference between an irradiated object and a contaminated object?

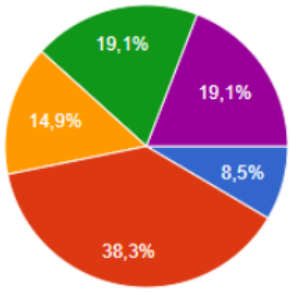


Figure 8. Answers to the second question.

3) Do teachers of other subjects, in your schools, share the idea that science subjects (Physics, Chemistry and Biology) are very far from the reality of students?

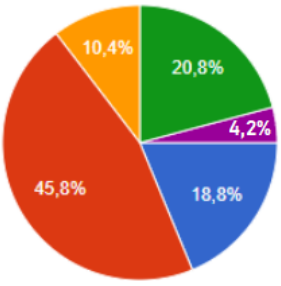


Figure 9. Answers to the third question.

4) Are the topics related to synchrotron radiation very far from the reality of the school environment?

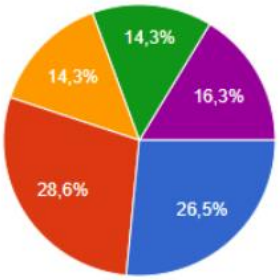


Figure 10. Answers to the fourth question.

After participating in the technical visit to CNPEM, the teachers were invited to reflect on their pedagogical actions, and on the importance of connecting the contents of these laboratories to their students. For instance, acording to one teacher:

> *My experience at Sirius, as a teacher, was immensely fruitful. In terms of knowledge acquired during the visit, I was able to enrich my Physics classes, which deal with the subject of Modern and Quantum Physics. As a scientist, being in contact with other colleagues who do excellent work in state-of-the-art laboratories in Brazil was very rewarding and motivating. I am particularly interested in scientific dissemination and the connection between what is produced in large science centers and the school. So I hope to be able to visit Sirius again and, who knows, with my students.*

V. CONCLUSIONS

According to the responses and experiences of the 60 teachers invited to this visit, we concluded that there is a need for a closer approach between applied science research and teacher training, whether initial training, during college, or in continuing education for teachers who are already in

schools. The concepts related to electromagnetic radiation, which were well present in several stages of the technical visit, need to be linked to middle and high school curriculum, and for that, other teachers need to carry out this type of visit, with the concern of universities and research centers in providing materials for the aid and study of education professionals.

The research group maintains contact with the 60 professors and, in the future, after five years of the visit, it will carry out an activity to understand how the teaching practice was modified after a visit to the largest scientific installation in Latin America.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon reasonable request from the authors. All participant subjects are above 21 years old, gave their image consent, and agreed to participate in this research. This work was carried out according to the principles described in the journal's ethical policy and informed consent for publication was obtained from all participants.

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