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The light: science and applications

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Abstract: “The light: science and application” is a project originally applied to fourteen to sixteen-year-old students of Laimos Junior and Senior High School the Municipality of Prespes, in the North Western Greece, although it was originally designed for slightly older students. The project aims to increase students’ motivation and interest in science by renewing the corresponding educational material, implementing modern teaching methods and bringing them into contact with the work of university scientific laboratories. The project is based on the collaboration among schools, universities and scientific laboratories. It encourages the use of new teaching methods and applications in the classroom and the contextualization of STEM learning.

Keywords: STEM, light, science, applications, technology

Introduction

Nowadays, it is obvious that modern has a significant role in economic and technological progress, e.g. computers are based on the physics of semiconductors and, consequently, on quantum mechanics while nanophysics affect a variety of products like colors, varnishes and medicines. On the other hand, science school curricula are conservative in general, especially in Greece, and hardly include the modern physics and its applications [1, 2]. As a result, most people not only consider science boring but also do not seem to realize its impact in our everyday life. Engineering, farming and other jobs may change significantly in the future because of scientific achievements, yet students do not really understand it. One of the school goals is to help our students acquiring more professional skills and make increasingly informed future career choices [3, 4].

Concept

The main idea behind our project is to treat a scientific subject in a way that will include not only different sciences (e.g. physics, chemistry and biology) but also applications and technology. This approach connects science to everyday life and meanwhile makes it interesting [1].

Implementation

Students who participated were involved in different activities inside and outside the school, which were divided into four different categories: Imagine, Feel, Create and Present, as described in the O. S. O. S. project guide In the first stage (Imagine Part), the students formed groups [3,4] and started thinking and discussing about light: what is it, its importance for life and its possible technological applications. They also brainstormed on their needs and their expectations. Then they collected

information about the light and, under the instructions of their teachers, presented their results to each other. Also, they were introduced to the particle theory of light (**Isaac Newton, 1643- 1727**), to the electromagnetic theory of **James Clerck Maxwell (1831- 1879)** and to the fundamentals of modern quantum approach. In this section we used the following simulations originally developed by the University of Colorado for educational purposes [5, 6]

<https://phet.colorado.edu/en/simulation/wave-interference> (wave interface)

<https://phet.colorado.edu/en/simulation/blackbody-spectrum> (blackbody spectrum)

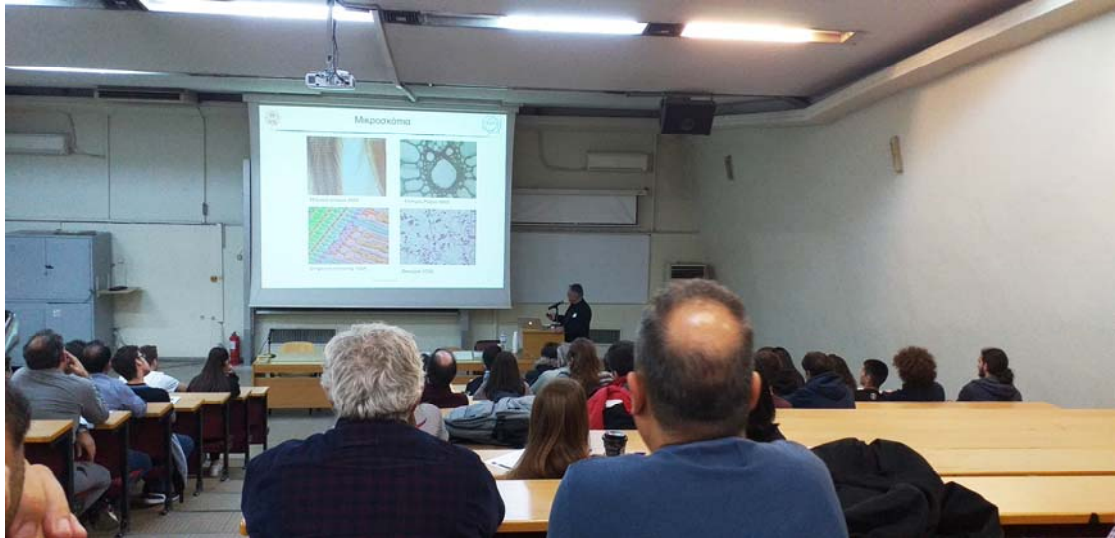
<https://phet.colorado.edu/en/simulation/legacy/photoelectric> (photoelectric phenomenon)

<https://phet.colorado.edu/en/simulation/molecules-and-light> (molecules and light)

<https://phet.colorado.edu/en/simulation/legacy/quantum-wave-interference> (quantum wave interface)

In the second stage (Feel Part) students took part in activities inside and outside the school. Inside the school they made characteristic experiments of reflection and refraction (with mirrors and lenses) which combine physics, geometry and trigonometry. Additionally, they learned how to prepare and use microscopes and stereoscopes and designed a simple photosynthesis' experiment, an activity that involved Chemistry and Biology. Also, a group of our students took part in the Event of Eratosthenes' Experiment (Thursday, the 21st of March 2019) which was organized independently by Ellinogermaniki Agogi Private School and the Union of Educational Science Laboratory Centers.

As far as the activities outside school are concerned, a group of sixteen years' old students went to Thessaloniki on Wednesday, the 27th of March, 2019, to participate in the "15th International Particle Physics Masterclasses" (see Pict. 1), which was organized under the authority of the local Physics' Department. There, they had the chance to learn about particle physics and work on a real CERN experiment.



Picture 1: “15th International Particle Physics Masterclasses” (Physics Department, Aristotelian University of Thessaloniki, Wednesday, the 27th of March, 2019).

Furthermore, our school began collaboration with the University of Crete not only for instructing purposes during this project but also for bringing our students into contact with a pioneering Greek university and a research center of excellence. So, our school decided to organize an educational tour to Crete from the 17th to 22nd of April 2019. The students visited the Departments of Physics, Biology and Chemistry of the local university (see Pict. 2), the Foundation of Technology and Research a few kilometers outside the Heraklion City and the famous Crete University Press. There, a group of them had an interesting discussion with Stefanos Trachanas (see Pict. 3), the former director of this organization. Next day, we visited Kournas’ Lake and Knossos’ Palace, where we had the chance to admire color combinations in nature and in the constructions of a famous ancient civilization. We also wanted to visit the new University Observatory on the mountain of Skinakas, but unfortunately the weather conditions prevented this.



Picture 2: students of Laimos Junior and Senior High School in the Biology's Department of the University of Crete.



Picture 3: students discussing with Mr. Stefanos Trachanas.

In the 3rd stage (Create Part) students studied the atomic structure as well as the fundamentals and the applications of LASERS. They also manufactured the characteristic atomic models and a simple laser in the school laboratory of technology under the responsibility of Mr. Grigoris Gemenetzidis.

Finally, in the 4th stage (Present Part) students were asked to show their work, their constructions and some characteristic experiments in an event open to their parents, to local authorities and local society. Also, some of them prepared to participate in the final O. S. O. S. students' conference (it was initially planned to take place during last March in Athens), which finally became an on-line event (6- 8 of November 2020) due to the pandemic of SARS-COV2.

Conclusions

The students' feedback was overall very positive. This was a unique opportunity for them to experience modern science and its applications from many points of view. One student wrote for her experience "Although the project seemed complicated and difficult in the beginning, we finally realized how scientists actually work and what they do". According to another student, the experience was very interesting and gave him much more understanding in the professional sphere. In general, despite the difficulties, the whole project was creative and interesting for all the participants, making students to develop a positive attitude to science.

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The O. S. O. S. project in Limos Junior and Senior High School was led by Dr. Ioannis N. Velonakis, teacher of Physics, Maria Georgiou, teacher of Chemistry and Biology, and Grigorios Gemenetzidis, teacher of Technology (all teachers of Limos Junior and Senior High School the period 2018- 2020). The students who took part were from the 3rd class of Junior High School and from the 1st and the 2nd Class of Senior High School. All the students were between fourteen to sixteen years old in the period of 2018-2020, although the project was originally designed for slightly older ones. The author, the school principal and the whole team would like to express Special Thanks to

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- Dr. Eleftheria Fanouraki (Department of Biology, University of Crete)
- Mrs. Maria Fouskaki (Department of Chemistry, University of Crete)
- Mr. Fotios Pontikakis, teacher, director of Vamos' center of Environmental Education

For the time they did spend with our students within 17-22 of April, 2019.

Biography

Dr. Ioannis N. Velonakis is a Post Doctoral Researcher of the Physics' Department (Solid State Physics Section) of the National and Kapodistrian University of Athens. He was born in Athens in 1980 and he has got a Degree in Physics (2002), an Msc in Material's Physics (2005) and a PhD in Solid State Physics (2013) in the National and Kapodistrian University of Athens. His research interests are about Theoretical and Computational Solid State Physics, especially with Monte Carlo Algorithms, Phase Transitions and Critical Phenomena. He has published about twelve (12) original research papers on scientific journals with referees and has made four (4) announcements in international scientific conferences. He also works as Physics' teacher (since 2008) at secondary Greek schools, especially at Limos Junior and Senior High School, Prespes, Florina (since 2009), trying to make his subject interesting for his students.

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