

The 8<sup>th</sup> International Scientific Conference  
eLearning and software for Education  
Bucharest, April 26-27, 2012  
10.5682/2066-026X-12-105

**ELEMENTS OF INTERDISCIPLINARY INSTRUCTION IN THE NATURAL  
SCIENCE CURRICULA**

Stefan ANTOHE

*Faculty of Physics, University of Bucharest, Atomistilor Street, Bucharest-Magurele*

*E-mail: santohe@solid.fizica.unibuc.ro*

Catalin CHITU, Alexandru Catalin TITEI, Sabin MARCU

*National College Nicolae Grigorescu, Campina, Energetic High School, Campina, Romania*

*E-mail: catalinchitumail@yahoo.com, alexandru.titei@gmail.com, sabinmarcu@gmail.com*

**Abstract:** *Natural phenomena can not be treated and understood in the context of a single discipline. School projects in which students are engaged, developing content and working methods that do not involve strict barriers between disciplines. In addition, there are students capable of high performance, students which have formed interdisciplinary skills and skills transfer. For these students, interdisciplinary approach to content and physics phenomena represents the usual way of working. Interdisciplinary learning can be applied in the context of differential treatment of students and of the learning content respectively. Differential treatment of students is a necessity in terms of diversification of skills, learning styles, educational profiles and their future professions. Students learn to enjoy those parts of the curriculum that is close to areas where they are passionate. Therefore, the teacher is able to launch this challenge to students. Attracting students to science has multiple results, such as attending school curricula in good condition, getting school performance in this area, increasing the number of future specialists in natural sciences. Therefore, our article presents elements of the physics discipline integrated in an interdisciplinary treatment of the contents. In this context, we intend to show that is possible to developing the projects which have the objectives to build graphic user interfaces used in physics learning process, or to control a continuous wave laser beam by a simple electronic circuit. Also, our article presents some laboratory experimental subjects with extensive content that can be discussed in the differentiated treatment to physics discipline. We estimate that in terms of interdisciplinary process, physics learning is a positive factor which leading to the complete and unit educational products for school curricula.*

**Keywords:** *Natural phenomena, Interdisciplinary learning, Laboratory experimental subjects, School projects*

## **I. INTRODUCTION**

The challenges of society's multiple transformations over the last decades are closely related with formal, non formal and informal education. The complex and integrated character of certain social phenomena such as globalization, the information boom, interculturality, migration etc call for an educational approach adapted to a continually changing society.

Keeping up with today's challenges means the ability to swiftly and efficiently switch between different disciplinary domains, the capacity to collect, synthesize and use skills and competences gained through studying diverse disciplines together.

The development of human personality, of it's ability to act autonomously and creatively in variously situations in life, lead to personal decisions about the content and methods of learning. In

this context, the current scholar curriculum means the introduction of Natural Sciences as a domain and method of integral approach of pluri disciplinary, interdisciplinary and transdisciplinary themes.

The integrated approach of the curriculum makes bringing the school closer to real life possible, environment in which solving concrete problems involves calling onto knowledge and competences that can no longer be restrained to the strict context of one single discipline.

Certain themes can be treated multidisciplinary, being subjected to analysis from the perspective of multiple disciplines that correlate to clarify presented problems.

The appearance of Science as an interdisciplinary study object involves intersecting different curricular domains of formal disciplines: Physics, Chemistry and Biology. In the interdisciplinary approach the strict limits of disciplines are ignored, seeking themes common to the different study objects and planning the development of abilities, of transfer of methods and competences between disciplines. The complementary role that computerized information technologies has in the integrated approach of the curriculum at all levels: monodisciplinary, multidisciplinary, interdisciplinary and transdisciplinary should not be underrated.

Recent studies in the domain of the growth of formal and informal education quality shows that the integrated approach of the curricula from the perspective of interdisciplinary develops and emphasizes the global style of learning of the students [1]. In this regard, certain educational platforms supply students, who prefer the global educational style, supplementary information and feedback, by making additional learning sequences available [1, 2]. Therefore, the organized character of training based on clear teaching strategies leads to the creation of connections with other content units and making the transfer between different curricular areas possible in the case of these students.

In this study we present an example of integration on the horizontal of the school curriculum in the case of the “Light” theme. We reunite in this process several study objects belonging to the curricular areas: Mathematics and Sciences, and Technologies. In this context we present experimental alternative laboratory methods practiced for the measurement of certain physical parameters, but also informatics applications developed by us for the collection and analysis of experimental data.

We believe that this integrated approach of themes and learning units develop in the students the research and innovation spirit, a better correlation between disciplines and a growth of the information transfer capabilities and earned competences.

## II. LIGHT-NOTION AND PHENOMENA

Studied and researched ever since the Ancient times, the light represents a vast area of interest even to this day. From the natural light emitted by stars to the artificial light produced by quantum transitions with the help of different devices built by man, the light still presents a great importance to life.

Practically, in a large measure, life depends on the presence of light. Because of the phenomena of photosynthesis of living organisms that contain chlorophyll transforms light energy into chemical energy, fixing the carbon dioxide from the atmosphere and eliminating the oxygen necessary for the breathing process. The chemical equation corresponding to the photosynthesis process contains the formula of sugars as reaction products [3, 4]:



The compensation point of light is represented by that value of light intensity at which the oxygen emission by photosynthesis is equal to its absorption by breathing. The survival and growth of plants is not possible but with the lighting above the compensation, for a few hours a day. It can be observed the fact that photosynthesis occurs until the smallest values of light intensity. The conversion efficiency of light energy into chemical energy is contained in the interval between 3 and 6 percent [7]. This percentage depends on the frequency of the light converted in the chemical reaction, of the temperature and the carbon dioxide concentration in the atmosphere.

The existence of microalgae, through which photosynthesis fixates the carbon dioxide from the atmosphere, presents economical interest because of the possibility to produce energy from

biomass. Through biological processes, carried out in the presence of light, gas and liquid fuels can be obtained such as hydrogen, methane, ethanol and certain oils [5, 6].

Chronologically speaking, ever since the Ancient times the Greek mathematician and philosopher Pythagoras references the corpuscular character of the light. The corpuscular hypothesis of light is developed much later on by the renowned English scientist Isaac Newton (1643 – 1721), who claimed that light is made up of particles emitted by light bodies.

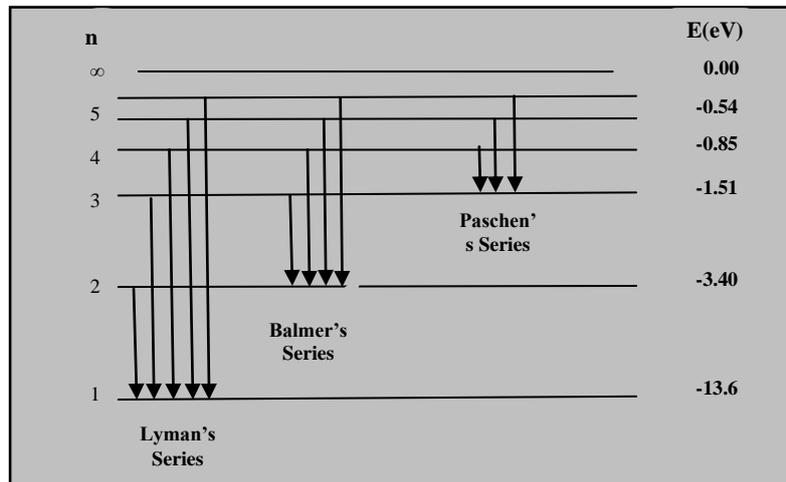
Following the experiments of Thomas Young (1773 – 1829) and respectively those of Jean Augustine Fresnel (1788 – 1827), the wave nature of light has become an undisputed scientific subject. Systematically researching interference phenomena and light diffraction, Young measures the wavelength of light and discovers the link between the color of light and its wavelength. At the same time, by the discovery of light polarization, Fresnel reaches the conclusion that light is a transversal wave. This aspect is later covered by Scottish physicist James Clerk Maxwell (1832 – 1879), the one who founds the theory of the electromagnetic field. Alongside this theory he reached the conclusion that light is of electromagnetic nature, the propagation speed of light in void having the same value as the propagation speed of the electromagnetic field. Furthermore, the light radiations from the visible domain occupy a narrow area of the wavelength from the electromagnetic field spectrum (between 400 nm and 750 nm at the propagation of light in void).

The theory of the electromagnetic field could not explain the emission of light by incandescent bodies. The emission and absorption of light could be explained later based on the fundamental quantum theory developed by the German physicist Max Planck (1858 – 1947).

The laws characteristic to emission and absorption specters of atoms have been deduced based on two postulates introduced by the Dane physicist Niels Bohr (1885 – 1962). Again the laws of quantum physics explained successfully the behavior of atoms. The lines of spectral series emitted by hydrogen result in the quantum transitions of the atom. The atomic model proposed by Bohr certified the empirical formulae of the spectral series for the hydrogen atom in the visible domain, the formulae initially deduced by Johann Jakob Balmer (1825 – 1898) and Johannes Rydberg (1854 – 1919):

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \quad (2)$$

the formulae in which  $R=1,097373 \cdot 10^7 \text{ m}^{-1}$  is Rydberg constant, and  $n$  takes integer values: 3,4,5,6.....



**Figure 1.**The diagram of energy levels in the case of spectral series for the hydrogen atom

The emission phenomena and light absorption by molecules and atoms, conditioned by the quantification of energy states, have led to the separation between spontaneous emission and stimulated emission of radiation analyzed for the first time by Einstein in 1917.

At thermodynamic balance, the population of energy levels from a substance drops as their energy grows, according to the relation:

$$N_2 = N_1 e^{-\frac{E_2 - E_1}{kT}} = N_1 e^{-\frac{h\nu}{kT}}, \quad (3)$$

relation in which  $N_1$ ,  $N_2$  represent the number of atoms excited on the energy levels  $E_1$ ,  $E_2$ ;  $k$  is Boltzmann's constant (1844 – 1906);  $T$  is the absolute temperature of the substance ( $E_2 > E_1 \rightarrow N_2 < N_1$ ).

After realizing of the inverse population ( $N_2 > N_1$ ) and the emission simulated by the radiation, in 1960 took place the construction and patterning of the first LASER device with solid state. The creator of the first operational laser, the ruby laser, was the American scientist Theodore Harold Maiman (1927 – 2007).

A similar mechanism of the LASER device can be encountered on certain living organisms as well. The biological process of light production is called bioluminescence and is present at some marine protozoan from the flagellate family (noctiluca miliaris), at some fungi (armillaria mellea) and fireflies. These biological organisms synthesize a photogene substance named luciferin, substance that oxidizes in the presence of oxygen. The oxidizing process being exothermic, it leads to the modification of the energy of the substance having as a result the excitation of the luciferin molecule. The return of the luciferin molecule to the fundamental state is accompanied by the emission of light radiation with the wavelength of about 490 nm.

On the other hand, to understand the light phenomena, but the structure of matter as well, the scientists utilise on the large scale laser fascicles. The phenomena of bioluminescence, present in some internal processes of living organisms, can be studied and reproduced in laboratory conditions with the help of the laser device. In this case the phenomenon is called fluorescence and is an induced process, using laser fascicles. The laser induced fluorescence (LIF) is a microscopically method used for the study of molecular structures, the detection and selection of molecular species, their visualisation by diverse experimental methods [9]. Practically, species that are to be examined are excited with a laser fascicle. By unexciting them, light radiation is emitted with a lower wavelength that in the case of the incident laser fascicle, called fluorescence radiation. The analysis of fluorescence radiation supplies useful data about the internal configuration of the studied probe.

### III. EXPERIMENTAL LABORATORY METHODS

**Relating to the light phenomena, formal and informal education can be the host of educational projects.**

During the experimental activities connected to the study units from the Optics chapter we have promoted training strategies based on alternative study methods. In this area we recall experimental alternative methods for determining wavelengths of a laser radiation.

The differentiated training is tightly connected to the integration of educational software in the laboratory lesson. In this area we have developed applications that have the role of calculating and storing in a short time the values of physical parameters. These graphical user interfaces allow users, teachers and students, to perform calculations in a reduced time for physical sizes to determine and give useful information about the obtained values.

The light phenomena behaviour can be analysed with the help of the computer and information technologies. The software part is acquired or developed in the area of certain projects initiated at the level of the teaching unit.

The design and development of graphical units for the collection, calculation, verification and validation or invalidation of measurements taken in a laboratory, is proven to be an efficient work method and ensures a far greater freedom in the didactic area for the concentration on practical aspects of the experiment. Another advantage is the insurance of feedback in good time for the students [8].

The applications are developed using the programming languages: Visual Basic, Delphi, HTML5, CSS3, JavaScript (Coffee Script). The applications created have a modular design, which brings an advantage in using them during alternative laboratory experiments.

In the development of graphical applications presented in this article we have taken into account the evolution in time of our projects, starting from the usage of relatively simple programming environments (Visual Basic, Delphi) and continuing with applications that use complex environments as node.js, HTML5 [14,16].

The HTML5 and node.js have been utilized to create an application implemented as a standalone web service, application named “Nikola Handbook”. This application offers a flexible, extensible and usable platform for sharing scientific calculators based on distinct solving patterns.

The main focus point of the application is the snippet. The snippet is the conceptual representation of the scientific calculator modeled after a solving pattern of a specific problem, using abstract inputs and outputs, and the functions that tie them together.

A snippet can be accessed from three different sources: Database (via the bundled mongo db binary); JSON Package (via download or file copy); Instant Creation (via the formulae parser).

All the snippets are bundled into a JSON package [15]. Any snippet can be saved and downloaded as a JSON file, and used later, either via the HTML5 read API. The application supports the dragging of files into the browser window, and, therefore, a much easier integration with the operating system.

Also, a snippet consists in three types of documents used: for the inputs, outputs and the functions that tie the two types of data.

From the user’s point of view, the snippet is represented by two different contexts: “View” and “Edit”. The “View” area includes controls for saving the snippets in the database, deleting it, exporting the calculation history under a CSV format, downloading the JSON representation of the current snippet, closing the window or resetting it, and a link that does the transition between the “View” and “Edit” contexts. The main window of the “View” context consists of inputs and outputs. It is what the user will see and utilize. The “Edit” area consists of inputs that automatically modify inputs and outputs (including functions) of the snippet. It is a fully-pledged snippet editor [18].

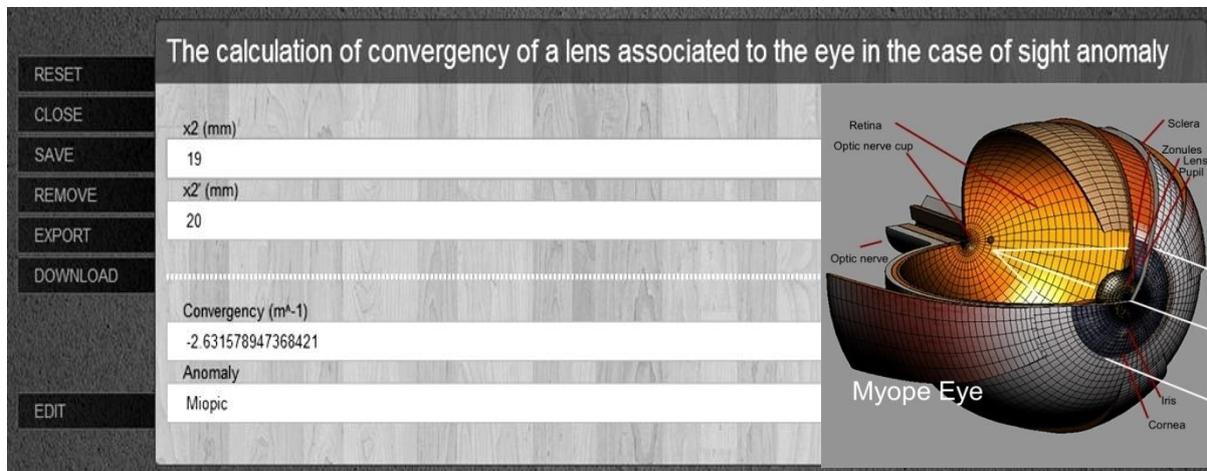
The main menu is built from two sections, one is a list of options and actions, and the other a list of snippets saved in the database. The entire graphical interface of the application is simple, uncluttered and usable.

For example we will take the calculation of lens convergence associated to the eye in the case of a sight anomaly. It is necessary to construct the source code of the JSON snippet to generate the calculator [16, 17]. This code will generate a calculator similar to the one illustrated in the figures below, in correlation with the three hypostases (healthy eye, myopic eye or long-sightedness eye) [21].

The physical-mathematical relation used for calculating lens convergence in the case of sight defects requires mentioning:

$$C_l = \frac{x_2 - x'_2}{x_2 x'_2}, \quad (4)$$

In this relation has been considered the fact that the eye can perceive an object clearly, indifferent of the distance to it, the parameter  $x_2$  representing the image distance of the eye and  $x'_2$  being the distance between the image in the presence of the optical lens associated to the eye.



**Figure 7.** Image with the “View” area of the GUI in the concrete case of sight anomaly (Myopic eye)

## IV. CONCLUSIONS

Observed and researched from the oldest times, the light is the object of many disciplines. Either it is about living or dead matter, the light phenomena are present. The consequences of the interactions between light and matter represent useful indicators for the comprehension and interpretation of the concept of light.

The notional and phenomenological content of light is the common parameter of a set of domains (corpuscular optics and wave optics, laser physics, elements of chemistry and biology) that, co articulated, form a whole [10]. It is the step which multidisciplinary makes towards transdisciplinary.

The advantage of using the graphical interfaces that we built in the domain of Science is to increase the interactivity level, which leads to obtaining feedback at opportune moments [11]. Using G.U.I. in the teaching – learning – evaluation process develops visual training styles of educational partners and their orientation towards research [12].

Multidisciplinary and integrated treatment of concepts and natural phenomena generate synthetic contents that keep, still, the curricular realities of study disciplines [13].

The development of inter- and multidisciplinary projects is based on both notional contents, as on products realized in school laboratories. Therefore, image captures, audio-video edits, experimental devices and software applications created represent the useful component means for future educational projects. We estimate that the method of student training calling on multidisciplinary are the advantage of a much better opening in regard to the ensemble of aspects tied to the understanding and interpretation of nature.

## References

- [1] N. Stash, A. Cristea, P. De Bra, Explicit intelligence in adaptive hypermedia: Generic adaptation languages for learning preferences and styles, Proceedings of Workshop CLAH (2005)
- [2] K. A. Papanikolaou, M. Grigoriadou, H. & G. D. Magoulas, Personalizing the interaction in a Web-based educational Hypermedia system: the case of INSPIRE, (2003)
- [3] Ardelean, A., Mohan, G., Mihail, A. (2005). Photosynthesis. Biology textbook for 10th grade. Bucharest: All Publishing, (Chapter 1).
- [4] <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BiobookPS.html>
- [5] M.A. Borowitzka, In "Micro-algal biotechnology" Eds. M.A. Borowitzka, and L.J. Borowitzka, 257-287, Cambridge University Press, Cambridge, (1988)
- [6] K. Miyamoto, In "Recombinant Microbes for Industrial and Agricultural Applications" Eds. Y. Murooka, and T. Imanaka, 771-785, Marcel Dekker, Inc., New York, Basel, Hong Kong, (1994)
- [7] ^ Chapter 1 - Biological energy production">Miyamoto K. "Chapter 1 – Biological energy production". Renewable biological systems for alternative sustainable energy production (FAO Agricultural Services Bulletin – 128). Food and Agriculture Organization of the United Nations. Retrieved 2009-01-04.
- [8] Chițu, C., Inpuscatu, R. C., Viziru, M., 2010. Visual Basic Applications to Physics Teaching, Proceedings of the 5 th INTERNATIONAL CONFERENCE ON VIRTUAL LEARNINGICVL 2010. Bucharest University Publisher. Bucharest, Pages 403-409
- [9] Bunget, I. (1988). Compendium of physics. Bucharest: Scientific and Encyclopedic Publishing House, (Chapter 4, 5).
- [10] Moraru, S., Stoica, I., Miron, C., (2010). New Connections between Modernity and Tradition in the Teaching Process. New Connections between Different Field of Science. Proceeding of the 5th International Conference on Virtual Learning-Section Software Solutions, Bucharest University Publisher, Pages 90-94.
- [11] Iofciu, F., Miron, C., Antohe, S., (2010). Interactive Conceptual Maps Part of Constructivist Environment for Advanced Physics Teaching. Proceedings of the 5th INTERNATIONAL CONFERENCE ON VIRTUAL LEARNING, (ICVL 2010), Targu Mures, Bucharest University Publisher, Pages 95 – 100.
- [12] Malinovschi, V., 2003. Teaching Physics, Didactic and Pedagogic Publishing R. A., Bucharest, Pages 111-113
- [13] Cucos, C., (2006). Pedagogy. (2nd ed.). Iasi: Polirom Publishing House, (Part. I – Chapter 4)
- [14] Node.JS – <http://nodejs.org/>
- [15] JSON – <http://json.org/>
- [16] W3Schools HTML5 – <http://w3schools.com/html5/>
- [17] Express.js – <http://expressjs.com/>
- [18] Stitch - <http://github.com/sstephenson/stitch/> ( <http://github.com/sabinmarcu/stitch/> )