

Learning Science towards a Sustainable Development

Vila-Chã Baptista RM, Silva P and Costa MFM

Introduction

The learning of sciences can be very stimulating. One cannot say there exists a perfect pedagogical method but our experience proved that actually going through the situations makes it possible for the students to learn the concepts more effectively and efficiently. Concrete experiences help students acquire knowledge with more ease [1].

The objective of the project herein reported is to get the students to learn science and simultaneously awaken to the principles of sustainable development. In the context of the programs of various disciplines, the use of a general and globalizing theme will allow to integrate various areas of knowledge and contribute to better learning.

As collateral objectives, this project also intends to promote the level of literacy of the students and consequently of the society they belong to [2]. The United Nations entitled 2003-2012, the Literacy decade. Scientific literacy is fundamental for the development of our societies and humanity.

The project will be implemented in other schools, located in mountain regions, in different European countries, that will share our experiences and knowledge. A number of exchange visits of groups of teachers and students will be organized in order to enhance the sense of European citizenship among the participants in the project and there schools. Science fairs will be organized where the work developed will be presented to the community.

Characterization of the coordinating school and its region

The village of Vieira do Minho is located in a mountain region, in the foothills of the Cabreira mountain range, a few kilometres away from the Peneda do Gerês National Park in the interior of the northwest Portuguese region of Minho. The whole region has vast natural and patrimonial resources. The region has excellent conditions for production of electrical energy by ecologically safe methods: wind, water and solar. The people live of agriculture, small commerce, services, tourism

and industries. In general, they have little access to culture and the level of illiteracy is high.

The Vieira do Minho high school is frequented by 715 students, divided into six year levels from 7th to 12th grade. The teaching staff consists of 85 teachers, most of which with a permanent position in the school. Throughout various years several projects, directed toward furnishing the laboratories with the equipment necessary for the teaching of science, have been elaborated in the school successfully. The annual fair has been repeatedly successful and has counted with the participation of school students of the region, especially from primary schools. Special attention is given to the latter because they have limited contact with experimental practice.

One of the major concerns of the board of directors of the school is the fight against failure and dropping out. For this reason certain measures have been taken to promote and value all the competences acquired by the students and introduce methods of diversifying its evaluation.

This project will involve students from the 10th 11th and 12th grades. The disciplines more directly related with this project will be Physics, Chemistry, Biology and Geology. The school curriculum will be covered, always focusing on the principles of sustainable development.

Topics of the project covered in the Physics classes

World energy situation and energy degradation

After an individual study of various sources of informative text, tables and graphics containing technical data and opinions about different energy consumptions in various human activities, the yield of different processes and use of energy sources, the teachers will stimulate the students to make a critical analysis with a scientific foundation about energy problems and the rational use of energy.

The students are invited to analyze the situations of energy consumption on their daily life and suggest solutions for a more rational use of that energy. The growing consumption and daily energy waste will be discussed, especially the energy consumption associated with transportation. Therefore, a comparative research on energy consumption in the transportation sector will be requested. The Superior Technical Institute will be contacted so as to be able to use in our school a driving simulator that they have developed which allows the user to know at the end of each "trip", and in function of each form of driving, the consumption of fuel and the emission of pollutants.

Energy Conservation

The general law of energy conservation is one of the most important laws of physics. In the particular case of thermodynamic systems the 1st Law of thermodynamics calculate the variation of internal energy through work, heat and/or the absorption/emission of radiation. The most recent formulation of the 1st law of thermodynamics distinguishes heat from electromagnetic radiation and implies a calorimetric definition for heat (energy transfer due to a difference in temperatures).

For a better understanding of this law and of its implications, our students will be asked to analyze systems well known to them: computers, game consoles, household appliances, mobile phones, etc... By doing so they will identify the transfers of energy that occur in each system in the form of work and heat, always keeping in mind that in each transfer there is energy that is dissipated and consequentially the yield is always less than 100%.

It is important to emphasize the idea that energy is something that is always present in our lives and, when referring to the mountain regions in particular, that are colder in the winter, it is fundamental that the houses are energetically efficient. They should be thermally isolated and the material used in their construction should be chosen in accordance with the characteristics of the area, i.e. solar exposure, relative humidity, etc...



Figure 1. Panoramic view of the Vieira do Minho region



Figure 2. Compostor to be constructed and installed in the school.

Making use of solar energy

In this particular subject various activities will be organized that involve the use of solar energy. The students will learn about the conditions necessary for the use of solar energy for heating or even for the production of electricity.

The students will therefore be led to conclude that the use of solar panels has a positive yield. This way the student will relate the total potential irradiated by a surface with its area and the fourth potential of its absolute temperature (law of Stefan-Boltzmann) and to identify the zone of the electromagnetic spectrum where the potential irradiated by a body is at its maximum.

An educational visit to a school or institution that has these systems installed will take place and the installation of similar systems in our school will be studied. A competition between the participating schools will be held to construct solar collectors. In the end the best work will be rewarded and will be exhibited in all the schools involved in the contest.

Wind energy

The geographic configuration of Portugal, and in concrete of this region, allows the installation of aeolian parks only in high mountainous places. In the plain regions

the wind has very low average speed and therefore the energy produced is in such a way low that it makes it an economically impracticable project.

A wind generator gets its energy by converting the force of the wind into a binary one that acts on the helices of the rotor. The amount of energy transferred to the rotor by the wind depends on the air density, the area scanned by the rotor, and the speed of the wind.

The kinetic energy of a body in movement is proportional to its mass and to the square of its speed thus, the kinetic energy of the wind depends on the air density. The denser the air, the more energy received by the turbine. The colder the air the denser it is. At great altitudes, such as mountain regions, the air is colder thereby being denser. A typical wind generator of 1.000 kW has a rotor with a diameter of 54m, which implies an area of 2.300 m². This determines the amount of wind energy that a wind turbine can capture. Since the area of the rotor increases with the square of the diameter of the rotor, a turbine that is twice as large will receive four times more energy. The speed of the wind is very important for the amount of energy that a wind generator can transform into electricity; the amount of energy that the wind possesses varies with the cube of the average speed of the wind. If the speed of the wind duplicates the amount of energy it contains will be 4 times greater. After a study visit to the Cabreira mountain range wind collector park, the students will learn the concept of kinetic energy and energy transfer with greater ease. Small wind generators will be constructed to test the variation of electrical energy produced in function of the speed of the wind.

Topics of the project covered in the Chemistry classes

The Chemistry program for high school student's deals with certain topics related to this project, thereby integrating itself perfectly.

Atmospheric Pollution

The identification of the atmospheric pollutants is very important because it helps the students to understand that they have many opportunities to avoid erroneous behaviour in favour of the atmosphere. The region in question has, as a common practice, the burning of all types of domestic garbage many times without knowing the harm that is being done. It is not only illegal, but also responsible for the emission of toxic gases to the atmosphere and the cause of many fires.

The students will find the explanations for the reason why some natural agents, as well as some human activities, alter the concentrations of the troposphere constituents that normally exist in trace amounts [3]. Carbon monoxide, one such constituent, results from the combustion of carbohydrates and, in certain conditions, makes the atmosphere toxic and lethal to human beings.

The ozone layer

In a practical activity the students will be invited to observe, using protective eyewear, different light sources: solar light, ultraviolet light, and infrared light.

Following these observations they can compare the effects of irradiation on different objects (i.e. minerals, white clothes, bank notes, and detergent dust). In this same activity they can observe the protective effect of glass filters, perspex, and solar creams against UV radiation and compare the effect of mechanical filters and chemical filters (the case of ozone) on radiations.

In the process of dealing with the results of this activity, each group will analyze documents relative to the ozone in the atmosphere, systemize information on the consequences of the rarefaction of the ozone in the stratosphere, and interpret international recommendations for its preservation.

The chemical composition of water and pollution

The high-school chemistry program gives special attention to the study and analysis of water and aqueous solutions. Particularly, with respect to acid rains, experimental activities will be carried out that promote the study of the effect of atmospheric pollutants (CO₂, SO₂, etc.) on the pH of the rainwater. River water will also be analyzed. There will be an exchange of the water samples collected between the participating schools.

In the laboratory the students will analyze the pH and the conductivity of the samples:

- pH, translates the acidity of the samples (more or less elevated depending on the amount of acid dissolved in the solution);
- Conductivity is the parameter that indicates the mineralization, this is, the amount of ions and particles dissolved in the water.

Topics of the project covered in the Biology classes.

Biodiversity and protection of species at risk.

Field studies will take place for the identification of the different species, and their characteristic habitats, that belong to the biodiversity of Cabreira mountain range. An exposition panel will be created in order to show photographs of the species in their habitats. After making this inventory, the students will carry out a bibliographical research in order to identify the species that are at risk or in danger of being extinguished, as well as some possible causes for this situation.

Since this region has dams, special attention will be given to fishing. Considering that there exists the Law of the Minimum Sizes for Fishing, an inquiry will be elaborated to determine what kind and amount of fish exist in the region, what sizes when captured, and the evolution of the fishing activity in the past years. After analyzing and processing the data, a brochure will be elaborated with this information that will be distributed to fishing associations, tourism posts, etc...

To collect, recycle, and reuse

In the present school year a campaign to sensitize students to garbage separation will be elaborated. The first phase will include the display of posters with messages alerting to garbage problems. The posters will be renewed every week and after a month, one day will be dedicated to workshops organized by the students for the students of the school.

Containers for garbage separation will be placed in various locations of the school. These will be constructed by the students under the supervision of the Braval-Evaluation and Treatment of Waist Company, whose participation in the project will be requested.

The decomposition of vegetable or animal matter, that is essential to the fertility of the earth, is a common practice in rural backgrounds. This practice will be implemented in the recycling of the organic garbage produced in the school using a chemical and biological approach. This process can be defined as a controlled aerobic decomposition of organic substrate under conditions that reach temperatures high enough for the growth of thermophilic micro organisms. The temperature increase appears as a consequence of the release of heat in the microbiological degradation of the substrates. The result of this process is a product called compost that is stable enough to be applied in the ground, with advantages over synthetic fertilizers [4].

The decomposition of residues can also be obtained in the absence of oxygen, being at times incorrectly called of anaerobic decomposition. The resulting product of this process has characteristics very different from those of the compost.

The stabilization of the organic substance is done slowly and the temperature reached is not very high. The residue produced needs to be treated subsequently before being accepted as an organic additive of quality [4].

The students will construct a *compostor* that will be installed in the school. The container chosen must be of wood, containing two spaces, each one with approximately 1 m³. Chemically treated wood (i.e. varnish) not be used.

Geology topics

Geological landmark of the Cabreira mountain range

Earth is a dynamic planet. If the earth's internal heat had ended, and tectonic forces consequently stopped, the external geodynamic processes, driven by solar energy, would long have levelled the continents and equilibrium would have been achieved [5]. But internal and external forces continue to interact resulting in disarrangement, i.e. dynamic equilibrium.

Volcanic or seismic phenomena are of general knowledge but other less spectacular events, like constant rock transformations, also evidence that dynamism.

The rock cycle shows that each one of the three main rock groups: sedimentary, igneous, and metamorphic rock may be formed at the expense of others under new climatic or physical conditions and as the result of either internal or external forces [5].

The Cabreira mountain range is a granite massif that shares with others some characteristic landforms, but the most important features of this region are the periglacial landforms, granite pseudo-stratification very well defined, maybe the best on national ground [6].

The top and western hillside of the highest Cabreira Mountain, Talefe, is covered by granite slabs. These slabs originate from endogenous factors (structural and mineralogical characteristics of the granite) and exogenous factors (climatic conditions, particularly the frozen/thawed effects from the würmian glacial and post-glacial period).

The combination of these elements resulted in granite pseudo-stratification (Figure 3), which is still visible in the major massifs (Montesinho or Estrela). The breaking of these blocks covered the Cabreira hillsides with rocks 10 centimetres thick and sometimes a few meters of long [6].

The students will be induced to acknowledge the idea that the top and western hillside of the highest Cabreira Mountain is, in fact part of the local geomorphologic heritage and needs to be protected.



Figure 3. Cabreira granitic pseudo-stratification



Figure 4. Students on the field trip in the Cabreira Mountain range (Talefe)

Activities

1. Cabreira field trip, that took place during the present year, to observe the referred features and elaboration by students of a field trip guidebook.
2. Geological exchange between the schools with field trips whenever possible, that in Cabreira will be organized by the students. Students will have to collect rock samples covering national ground as well as photographs of local landforms.
3. Granite, from several places marked with pseudo-stratification, comparative study at mineralogical, textural and chemical levels. This study will be made in partnership with Geosciences Department of Minho University.
4. Preparation of one proposal to the European Association for the Conservation of Geologic Heritage to classify Talefe as a geo-monument.

Conclusion

Many of the questions that affect the future of the society must be approached in the school, making the students want to find out more about various topics such as: the increasing energy necessities, the climatic changes, biodiversity, the scarcity of spaces and resources, Man's interventions in the terrestrial subsystems and its negative impact in our environmental and thus to a sustainable development. It is of utmost importance to change the attitudes of the common citizen and society in general. So that this change of attitudes is verified, solid scientific literacy is imperative so as to assist us in the comprehension of the world we live in, to identify its problems, and to understand the possible solutions. Awareness and critical reflection on these challenges should be promoted. Our students will profit this opportunity of exchange of experiences and knowledge with other fellow students of other cultures. The participation in this project of schools of various European countries will give the project a fundamental European dimension.

Acknowledgement

The authors would like to acknowledge the support of the director of the Vieira do Minho high school, Jose Braga Fernandes, for his support and interest shown in the implementation of this project and the local authorities for their promise to participate in the development of this project, to Arcélio Sampaio for the information he kindly offered and for his work in the graphic arrangement of the presentation, and specially to Alda Ferreira for her support and comprehension. The activities and plans herein reported are inscribed in the frame of activities of the HSci network.

References

- [1] Kolb KA, *Experimental Learning: Experience is a source of learning and development*, Prentice Hall: Upper Saddle River, 1984.
- [2] Costa MF, *Science Literacy and Development in The European Union, Workshop The Challenges of EU Enlargement*, Malta, 20th-22th January 2005.
- [3] Ministério da Educação, Departamento do Ensino Secundário, Programa da disciplina de Física e Química A - 10º e 11º Ano.
- [4] <http://www.escolasverdes.org>
- [5] Plummer CC, McGeary D and Carlson DH, *Physical Geology*, International Edition, 9ªEd, McGraw-Hill: New York, pp.: 50, 2003.
- [6] Pereira P, *Aspectos Geomorfológicos da Vertente Norte do Maciço culminante da Serra da Cabreira*, Relatório de Seminário da Licenciatura em Geografia e Planeamento, Universidade do Minho, Guimarães, 2000.

Paper presented at the 2nd International Conference on
"Hands-on Science. Science in a changing education",
Rethymno, Crete, July 13 to 16, 2005.
