A prototype Physics Laboratory using only Renewable Energy Sources: The Case of a Low-Cost and Easy-to-Build Electricity Generator

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Abstract. *Physics Laboratories require the use of electricity in order to experiment in basic principles of physics. For example, a heat source is required when experimenting on Heat Transfer and an electric source for basic DC/AC study, Ohm's Laws e.t.c. Many laboratories use batteries for all those experiments, with well-known effects of their consumption to the environment, This study is based on the idea of discovering a way to produce the electricity that is required for all these experiments with the use of Renewable Energy Sources. We herein present one of the devices of that prototype Laboratory.*

Keywords. Easy-to-build Electricity Generator, Electromagnetism experiments, Renewable Energy Sources,

1. Introduction

A Renewable Energy Laboratory is distinguished by the extended use of renewable energy sources for the experimentation. The use of such kind of energy by the pupils in the process of experimentation leads to a positive view and understanding of environment friendly technologies.

In our study we present the construction of an easy-to-build device with low cost materials as a way to provide pupils with a hands-on exploration of generating electricity with water or human power. By constructing the model successfully, pupils learn and demonstrate the principles of generating electricity.

Figure 1 – Constructing the coils for the first device

Furthermore, they experiment on basic principles of Electromagnetism, Energy Conservation and Renewable Energy Production.

This is a thematic unit geared towards High School pupils and is suitable for teaching the courses of Physics, Technology and Environmental Sciences. By pursuing the objective to construct the model, pupils may develop complex cognitive and problem solving skills.

Pupils can also produce their own electricity necessary to reproduce fundamental electromagnetic experiments (which are mantandory in the curriculum of Hellenic Physics' Lab) like Ohm's Law, Electromagnetic induction, Alternative and Direct Current etc.

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Figure 2 – Building the stator

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2. Educational Methodology

Our goal in this study was for the pupils to approach the phenomenon of induction with relatively easy experiments. For this reason, the pupils are split in two groups and are given a worksheet which is based upon the aims and the objectives we describe in the next paragraph.

The worksheet includes the following steps of the scientific / educational by inquiry model [1][2]

- Trigger of interest
- Hypothesis expression
- Experiments
- Formulation of conclusions and proposals - recording
- Generalization - feedback – control.

2.1. Educational aims and objectives

Educational Aims
Pupils should:

- Acquire basic knowledge on phenomena that are related with magnets and electromagnetism.
- Practice on exporting conclusions via experimentation.
- Acquire a positive attitude concerning the use of renewable sources of energy.

Educational Objectives
Pupils should:

- Manufacture a Low-Cost and Easy-to-Build electricity generator.
- Describe the operation of an electricity generator and recognize the factors that play crucial role in the production of the electric current.
- Compare the produced electric current from the electricity generator with the one that we expected to get from the specifications of bibliography.
- Combine the operation of the manufactured electricity generator with the operation of major industrial electricity generators.
- Report alternative ways of operation of the manufactured electricity generator which are based on renewable sources of energy.

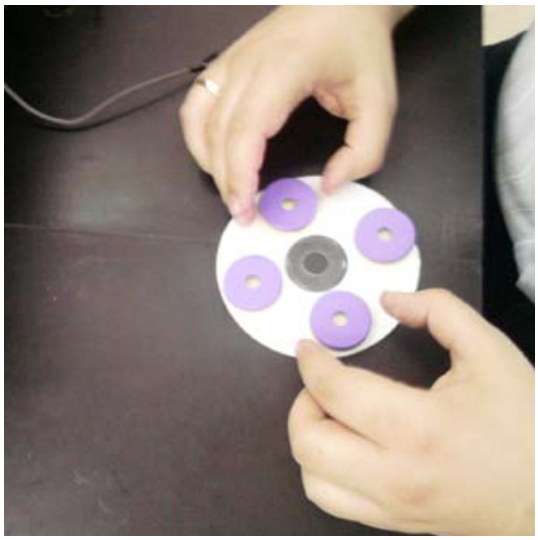

Figure 3 – Building the rotor

2.2. The Model in-depth

At the stage of Trigger of interest pictures and video of electricity generators are presented to the pupils Electricity generators that function with wind and water are selected to be presented in order to make more obvious the connection to renewable sources of energy.

In the stage of Hypothesis expression the pupils are left to formulate their opinions concerning the operation of an electric generator and the production of electric current.

In the stage of experimentation the two teams are requested to manufacture an electrical generator with simple and easy to find materials. Each team manufactures a different electrical generator so that in the end the pupils can compare them.

In the stage of Conclusions each team of pupils reports the final conclusions that are related with the operation of electrical generator and the production of electric current. The pupils are finally asked to choose one of the two generators based on criteria such as ease to built, lowest cost and production of current of higher tendency.

In the stage of Generalization the use of renewable sources of energy are presented to the pupils who are afterwards asked to find ways to replace the batteries in a renewable energy laboratory, especially those needed for the experiments of electricity (closed circuit, short-circuit, etc).

3. Building the devices

For our study we used materials such as: Plastic spoons, Magnets, Marking Pens, Wire connectors, Alligator Wire clips, a Multimeter etc. All of these materials are available in every school lab and easy to find for pupils, as well as the construction of the device is safe and the charge that the device produces is low.

The first team of pupils constructed an electric generator which was constituted of 4 coils adapted to a constant base (Stator) Fig. 2.[3] Each coil was made of 400 loops of copper wire (0,35 mm). In very small distance between the 4 coils pupils placed 4 magnets in a movable base (Rotor) Fig..3. In the utmost of the 4 coils pupils connected a LED light. As they rotated the magnets they observed that the LED light did not turn on, while the measurements of tendency that were recorded with a multimeter by the pupils never exceeded 0,2V.

Figure 4 – The coil for the second device

The second team of pupils constructed an electric generator which was constituted of a coil wrapped around a small paper box [4]. The coil consisted of 400 loops of copper wire (0,35 mm) Fig.4 and inside the box 2 magnets that had freedom of movement were adapted. In the utmost of the coil the pupils connected a LED light. Pupils turned the magnets with an axis adapted onto them and as they rotated the magnets they observed that the LED light turned on, while the measurements of tendency that were recorded with a multimeter oscillated from 0,8V(min) to 1,8V(max).

At the end of the experimentation phase the two teams concluded that the easiest to built generator with the best tendency measurements, was the second one. They also concluded that the way the magnets are moved towards coils is fundamental for the voltage measurements.

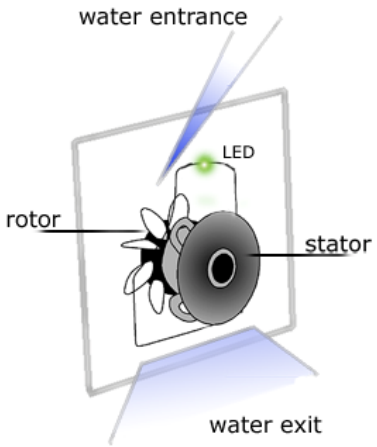

Figure 5 – The schematic of the final device

3. Renewable Energy Lab

After having constructed the two devices and finally having chosen the one which can produce higher voltage the pupils are requested to find a way to produce electricity using an alternative energy source like wind or water power instead of rotating the rotor by themselves. They chose to use water power and they created a construction shown in Fig.5

After their study in producing electricity pupils can use one of the devices they have already built for experiments on various physical phenomena, like: Ohm's or Joule's Law, Alternative and Direct Current Study and Safety related matters like short-circuit. The pupils had already experienced the difficulty of producing

electricity and voltage over 1V so they will have the opportunity to choose experiments that can be accomplished with devices 1 or 2. For example they explain why they can lighten up two LED lights only when they connect them in parallel and not in serial circuit. They understand why they cannot heat up water with those volts and why we use special low voltage LEDs.

4. Conclusions

The construction of the device helps pupils to understand and apply scientific concepts and principles, conduct scientific inquiry, work in groups and communicate. Additionally they increase their conceptual understanding of energy production through construction of a model hydropower turbine and increase their mechanical and conceptual skills through construction and operation of the turbine. Finally they comprehend the basic electromagnetic principles that are necessary for the construction.

5. References

[1] Kalkanis G, author. Educational Physics, Educational Technology and their Applications, Athens, 2007.

[2] Kalkanis G, author. Educational Physics, Athens, 2002.

[3] Foundation for Water and Energy Education, http://www.fwee.org/TG/wpmodel.html [visited 25-Jun-2010].

[4] Ultra-simple Electric Generator, http://www.eskimo.com/~billb/amateur/coilgen.html [visited 25-Jun-2010].

The whole process left excellent impressions to all of us. Our school opened up to the community, young and old people participated in the same path of learning and reflectionThe educational activities were not only confined to the classroom, but have been expanded into many areas of students' lives.

We believe that the science fair gave us the opportunity to promote and achieve objectives beyond the narrow framework of learning the lessons of science The two schools worked extremely well and the students with their teachers enjoyed their involvement during the preparation and presentation of the festival.

5. References

[1] Karatzia - Stavlioti, E. (2002). The interdisciplinary in Curriculum Studies: Examples from the European experience and practice. Review of Educational Affairs, Volume 7, pages 52-65.

[2] Fernando Cajas (1999), Public understanding of science: using technology to enhance school science in everyday life. International Journal of Science Education, Volume 21, Issue 7 January 1999 , pages 765 - 773

[3] Bob Campbell, Fred Lubben (2000). Learning science through contexts: helping pupils make sense of everyday situations. International Journal of Science Education, Volume 22, Issue 3 January 2000 , pages 239 - 252