Mechanical and Solar Energy Projects … in Action

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Abstract. *This is a brief outline of the projects undertaken by pupils of the 6th grade of the 9th Primary School of Rethymno focusing on mechanical and solar energy, which have been presented to fellow pupils and teachers, as well as local citizens, in an open school exhibition, a so called "science fair".*

Keywords. Mechanical energy, solar energy, science projects, science fair.

1. Introductory Framework

Thirty five (35) pupils of the 6th grade of primary school have dealt with the "energy" concept within a framework of a series of teaching interventions with experimental investigations (*formal science teaching and learning*), extra-curricular projects with mechanical & solar energy constructions (*non-formal science teaching and learning*) and a final presentation of project work by pupils to fellow pupils, teachers and general public in a science fair activity (*informal approaches in communicating science within a free choice environment*).

It has been reported extensively that the "energy" concept, being abstract in its nature, it is hard to teach and learn in science education (Duit, 1986; Solomon, 1992; Williams & Reeves, 2003; Leggett, 2003). Thus, the difficult task for teachers has always been to find creative ways in which the "energy" concept could characterized with more "concrete" accounts and registers for pupils, to "reify" some of its aspects in a sense, especially for primary school science. This can be combined with an approach of using or creating toys in the teaching and learning of "energy", within a more familiar framework for child life and culture (cf. Taylor, 1998).

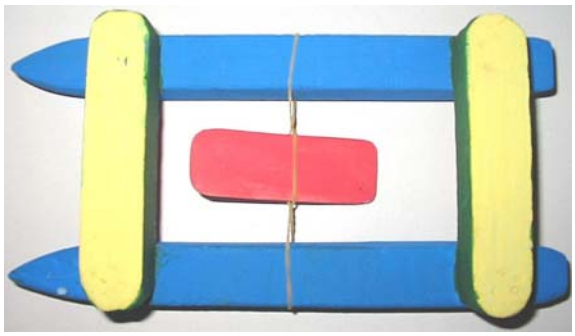
It is claimed that specific project work undertaken by pupils, alongside with experimental investigations and discussions in class, has contributed significantly in the conceptual development of "energy" for the primary school children of this study (cf. Tsagliotis 2004; 2005). The "energy" conceptual framework that provides the basis for the project work, as well as the study in broader terms, is "energy change" and "energy degradation", with foreground hints for "energy conservation".

2. Project work on mechanical energy

The pupils worked in pairs and they all constructed in class catamaran boats out of stripes of expanded polystyrene (DOW), which moved with a paddle gripped on a stressed rubber band. The conceptual idea we elaborated on is that the rubber band has "stored dynamic energy" (potential energy), which is changed to "energy of motion" (kinetic energy) rotating the puddle and moving the catamaran toy (see photo below).

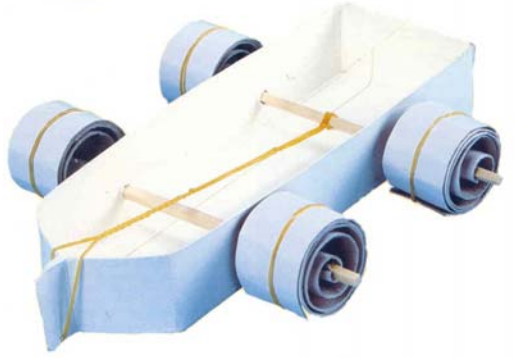
We also had to confront with "energy losses" due to friction or "the drag force" of the water as the catamaran moved in it. Thus, we had "energy degradation" due to "energy change into heat" when the toy catamaran with squared, uneven edges moved though the water. We had to deal with this "problem" by constructing more "hydrodynamic catamaran" toys, which moved faster and farther using more of the "available" mechanical energy, with less "energy

degradation" to heat due to "friction with the water". This is of course a qualitative, macroscopic approach of "energy change" and "energy degradation", but with a reified potential, thinking over "real" objects and their performance (see the improved catamarans we presented in the science fair in the photo below).



In a similar context "airplanes" or "boats" that moved with helixes and rubber bands were constructed by pairs of children as project work (see photo below).

Furthermore, a couple of "toy cars" moving with elastic bands were constructed by a couple of groups of children as an additional project on mechanical energy. Some children liked these toy car projects with elastic bands, but we had no time to make more of this kind and work further on their designs (see photo below).



3. Project work on solar energy

The children worked in pairs and developed projects and constructions related to applications of solar energy, which had to be functional and tested; therefore they had to develop certain techniques and deal with particular problems throughout the development of their projects. Children's project work dealt with three groups of projects in the study of solar energy: a) *solar water heaters*, b) *solar cookers* and c) *solar toys*.

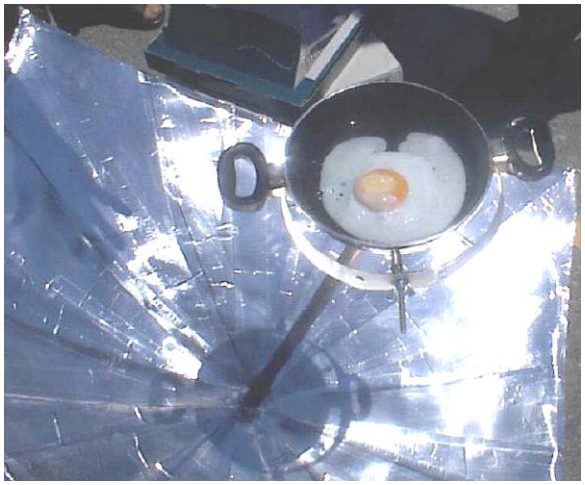
There are several designs of ***solar water heaters*** to choose from. The group of six pairs of children, who worked on these projects, chose to construct the following six solar water heaters:

- a "classic solar water heater" with flexible black tubes in horizontal and vertical arrays (see photo below)
- two "serpentine solar water heaters" with the flexible black tube arranged in an "S" shape
- a "spiral solar water heater" with the flexible black tube arranged in a circular form
- a "plastic bottles solar water heater" with the flexible black tube arranged in an "S" shape, passing through transparent, 1,5 litter soda bottles
- a "model solar water heater" with a spiral arrangement of a small plastic tube, where the water was gathered in a small container and circulated with a small water pump powered by 3 solar cells connected in a series.

There is a variety of designs for ***solar cookers*** to choose from, within three main categories:

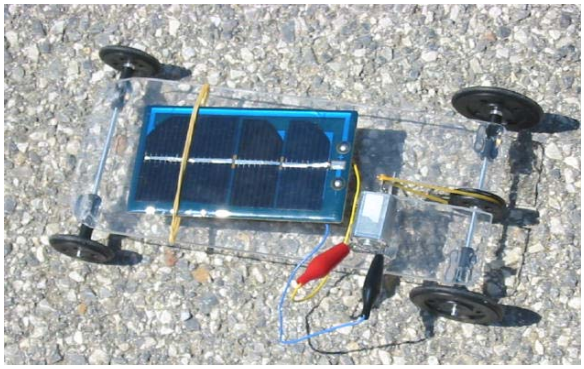
a) *box solar cookers*,
b) *open solar cookers with reflector panels* &
c) *parabolic solar cookers*.

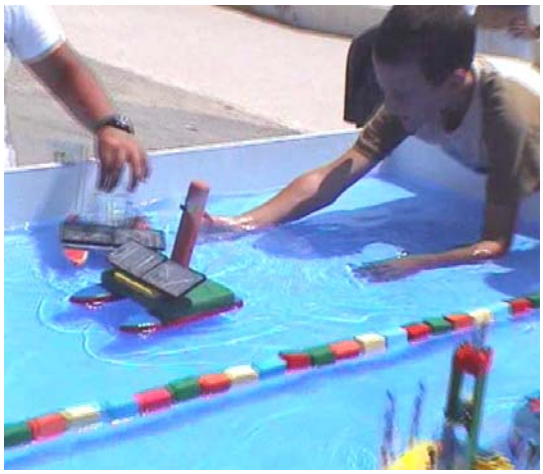
In the latest school science fair we chose to construct *three box solar cookers* and *three open solar cookers* with reflector panels, whereas we avoided the construction of parabolic solar cookers, which are generally considered more technical and difficult. Nevertheless, a *parabolic solar cooker* will be presented in the Science Fair organized within the *2nd HSci Conference*, which was constructed in an earlier school science fair (see in the photos below one example from the three categories of solar cookers respectively).



The preparation and the experimental construction of ***solar toy cars*** and ***boats*** took some time and effort, since quite a few detailed problems had to be resolved and an appropriate combination of materials needed to be arranged and purchased. Furthermore, a suitable kind of solar cells should be used for each construction to be functional. Thus, for example light and powerful photovoltaic cells were needed for the toy cars, whereas they were not necessary for the solar boats, which could move with smaller and heavier photovoltaic cells made out of amorphous silicone.

The children constructed several solar toy cars and boats, more than we had originally planned to construct. This happened because all children, when completing their projects in the groups of solar water heaters and solar cookers, wanted also to build their own solar toys. This is perhaps a good indication that a playful approach of "science in the making" or dealing with "hands-on science activities" for the particular purposes of project work, tends to be more attractive for children, triggering their interest and commitment (see below two indicative photos of a solar toy car and solar boats … on the move).





Being consistent with the conceptual framework of "energy" we briefly described earlier that is "energy change" and "energy degradation", the children have identified solar energy changing into heat warming up the water in the solar water heaters or cooking their food in the solar cookers. They also had to confront with

issues of “energy losses”, mainly heat “escaping” out of their solar collectors, tubes or water tanks and boxes in their solar box cookers and they had to find out effective solutions, insulating their constructions in better ways.

In the case of solar toys, more “energy changes” have been pointed out, such as solar energy changing into electrical energy and then into kinetic energy and finally “degrading” into heat due to friction in the various parts of the toys, with the surface of the ground or with their movement through the water. Again effective solutions had to be found and applied in order to confront with these “energy problems” to the best possible extent (cf. Tsagliotis 2004).

On the whole, the mechanical and solar energy projects to be presented in the Science Fair of the *2nd International Hands-on Science Conference* at the University of Crete in Rethymno, appear to be of interest for pupils, science teachers and the general public because they highlight, in a rather concrete way, aspects of the “energy” concept, through the goggles of a child centered approach, linking science with daily life activities and with simple, easily accessible and familiar materials, applications and/or constructions.

4. References

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