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# Visualizing and measuring by the computer the operation of hands-on educational devices - The case of solar water heater.

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## Abstract

We accept that science education should be based on a unified approach of nature and be linked with technology applications [1]. On the other hand, we believe that the use of information technologies at science education is justified mainly by the use of simulation of microkosmos procedures as well as by connecting experimental devices with the computer through sensors and actuators. Taking the above into consideration we planned and developed educational material (software and hardware) in order to support the study of heat transfer at primary school (age group 10-12 yrs).

Taking benefit of a common device (solar water heater) as a trigger of students' interest and as a hands-on activity, we aimed at the development of simple modeling by the students of all the procedures and concepts included in a curriculum unit (heat transfer). The modeling procedure was supported by visualization software of heat transfer – conduction, convection, radiation– through representation of photons exchange and ions motion. At the same time temperature was measured by sensors, and data were stored for further study. The sensors were applied on a model of a solar water heater (proposed to be) constructed by the students.

The education material is developed on the basis of the scientific method and with a view to allow an interdisciplinary approach. It provides teacher with instructional tips and scientific information and it includes worksheets for students as well as video-taped instructions of a step-by-step construction (with simple and everyday materials) procedure of the solar heater model. The presented approach is under evaluation for the time being. However, the first results seem to be promising.

## The content (heat transfer) on the solar heater model

Heat transfer is included in the vast majority of science education curricula for the age group of 10-12. In addition, students of that age are reported to hold misconceptions concerning heat and heat transfer. The above mentioned facts along with the presence of heat transfer in students' everyday experience and the direct relation of it with energy – one of the fundamental concepts of science, make the confrontation of students' misconceptions more than apparent.

Although heat transfer may be sensed on a macroscopic level, we believe that the procedure and the phenomena related with it may be best interpreted on the microscopic level [2]. This attempt to use the microkosmos elements and procedures in order to interpret macroscopic phenomena [3] systematically has already been evaluated at in-service primary teachers' training classes and has proved to be successful so far [4].

In the case of heat transfer we suggest three scientific models that are based on the microskopic framework: a) heat transfer within solid insulator (radiation / photons flow among molecules / particles), b) heat transfer within solid conductor (radiation among molecules / particles and free electrons) and c) heat transfer within fluid (molecules flow).

## The educational method

The software is based on the scientific method, as modulated to an educational version. We have chosen to use this method as we believe that it also satisfies a more general objective of science education, namely that of the development of procedural knowledge along with the factual one. The practice in order to acquire procedural knowledge contributes to the development of an algorithmic logic, which in turn offers one the ability to develop models for the description, interpretation –and even prediction– of the physical phenomena.

The educational scientific method may be divided, roughly, into the following steps:

- Trigger (motivation of students' interest).
- Discussion (formulation of hypotheses)
- Activities (experimentation/construction)
- Conclusions (approach of scientific model)
- Generalization (application/feedback)

## The instructional approach

The educational material is designed to be used as a supporting material for teaching Heat Transfer to students of the fifth grade of elementary school.

It is proposed that the students will make use of the carefully designed worksheets that will direct them to:

a) get interested / triggered by the software material

b) discuss with their peers and teacher (Socratic dialogues) and express their hypotheses guided by the questions, which are included in the software are proposed to be presented by the teacher and derive from students' misconceptions reported in literature

c) construct a simple solar heater model by the help of their teacher and the videotaped instructions

d) take measurements by applying thermal, and in future, light sensors on the solar heater model and using appropriate software [5]

e) describe and interpret the ways that heat is transferred according to the scientific models included in the software

f) state their conclusions and compare them with those presented in the software

g) apply their conclusions and the scientific models to other circumstances provided by the software, like the case of central heating.

The suggested learning outcomes may be described as follows:

Students are supposed to:

- Realize that the heat flows from places of higher temperature to ones at lower temperature.
- To develop an understanding of the two basic ways in which heat is transferred (radiation/conduction) in solids and convection in fluids (i.e. liquids and gases).
- To conclude that radiation is energy transfer, which does not require the presence of matter, whereas convection is the transfer of energy by matter movement.
- To discover that the high conductivity of metals is due to the free electrons.

## The educational material

Construction of a simple solar water heater with simple and everyday materials.

The experimental procedure that we propose includes the construction of a solar water heater model by using simple and everyday materials, with which students can experiment and observe the heat transfer models presented in the software.

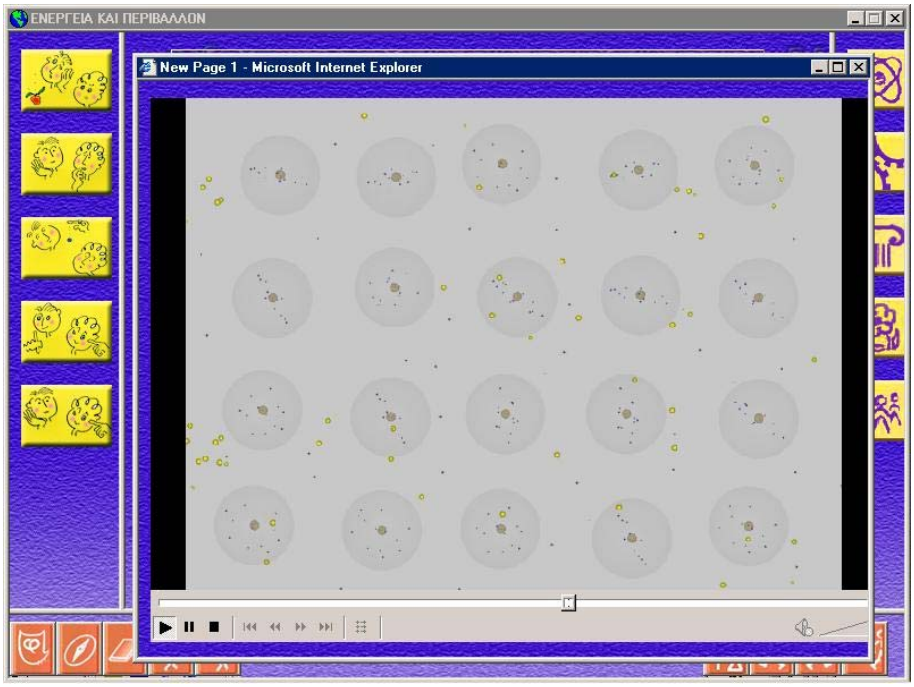
This activity has the advantage that –by using a model, which imitates an original industrial-made solar heater– it permits us to connect technology devices directly with the physical processes that govern their function [6,7].

The construction of the solar water heater can be made by simple materials that all students can easily obtain.

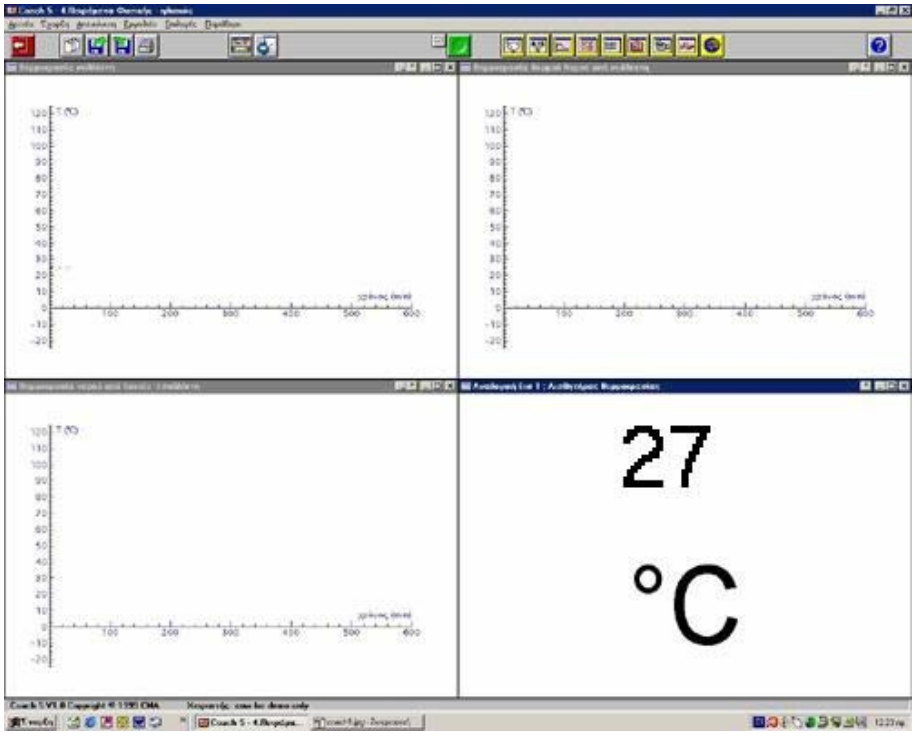

The proposed educational software includes comprehensive video-taped instructions for the construction of the solar water heater.

Data acquisition by sensors

During the operation of the solar heater model students may view on the PC screen the temperature value on several points of the device, whilst at the same time they may observe the microscopic procedures that take place through 3D visualization.




For the above purpose we used the Greek version (0.21) of Coach 5 along with the Coach Lab II console and CMA sensors.



## The educational software

The educational package includes multimedia software based on a Visual Basic form that calls HTML pages and 3D visualizations.

The software is designed on the basis of the above described scientific / educational method with an emphasis on the conceptual modeling procedure and allows an interdisciplinary approach of the subject. More specifically, each step of the educational method stands as a separate unit while the information it includes may be further studied on an interdisciplinary manner.

The teacher is provided with instructional tips and proposals that he may access from any screen of the software.

## The outcomes

We believe that students of this age will be able to follow the simple modeling process regarding the transfer of heat with the support of new technologies, as it becomes evident from prior applications of similar procedures in the same age group. The proposed educational package is now being evaluated in primary school and the first qualitative results are rather promising.

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