DEVELOPING REMOTE PHYSICS EXPERIMENTS TO FACILITATE THE DEVELOPMENT OF COMPETENCES OF SECONDARY SCHOOLS STUDENTS

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Abstract: Remote experiments have been used as a teaching tool for science and engineer education, and gained their role among the conventional ways of teaching. They have mostly been developed and used by universities for engaging students into experimental activities, where hands – on experiments are unable to fulfill educational goals, for several reasons. Though, remote laboratories are available in higher education, only a few secondary schools have access to them. In this paper we propose an educational concept where high school students can conduct a distant real experiment using the scientific method and investigate real life situations. As an example we set up the study of a passive model house. This kind of experimental activity will provide students the opportunity to apply Physics on practical issues, developing physics and experimental competences, which are vital in their citizen's life.

Keywords: secondary school remote experiments, experimental activity, distance education, competences

INTRODUCTION

Recently there has been the trend to encourage teachers to use experimental activities in science teaching. A lot of scientists proved the effectiveness of this standpoint – in 1938 Dewey set first the concept 'learning by doing'. Science experiments are vital in science education, involving hands-on and activity–oriented exploration to acquire scientific knowledge, develop competences, and attitude. Students can achieve all (knowledge, competences and attitude) through experimental activities (Kumar & Tobin, 1990) and actually they prefer science experiments than traditional face to face teaching (Roth, 1994). Although, it isn't always easy to set experimental activities because of lack of equipment, lack of time or even the complexity of the scientific topic itself.

Using new technologies in education can help to face these issues in various ways. Remote experiments are one of these ways. A remote experiment is a real experiment with real laboratory instruments and equipment that can be controlled by a teacher, or a student or any user from their personal computer through the Internet. Remotely controlled experiments have been used as a tool for teaching physics at higher education. The use of a remote experiment is most beneficial and helpful in domains, where it is impossible to perform the real experiment, or where there is no appropriate equipment available. Remote laboratories are asynchronous methods of learning, and there is no need to have the

multiplicity of equipment. Also a variety of experiments can be performed by the students when it is convenient on their own or in groups.

Searching through literature, with keywords: “remote experiments or laboratories”, “real experiments from distance”, “virtual experiments or laboratories” etc we came to the conclusion, that such experiments have been used mostly in the field of engineering and less in science education (Ma & Nickerson, 2006). Remote labs have been used and tested by university students and in some scientific topics it was stated that they are more effective than working with simulators (Scanlon et al, 2004).

EDUCATIONAL CONCEPT

In this paper we describe the educational concept where students in secondary schools will use the scientific method and study physic’s issues that concern their daily life. In this concept, we developed an educational website (Figure 1) which hosts a remote experiment.

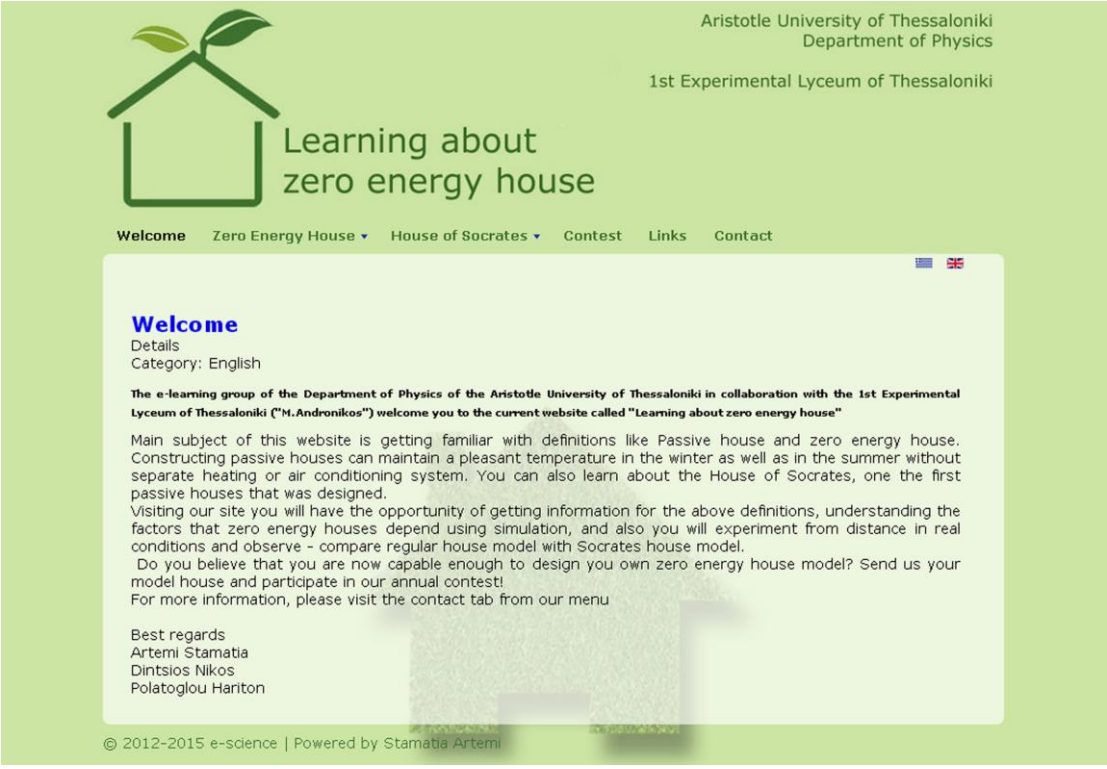

Figure 1. Educational website (http://e-science.web.auth.gr/zeroenergyhouse/)

This experiment engages students in measuring environmental parameters (temperature and sun intensity) inside and outside of a passive house model which is placed on the roof of the building of our department. This way, students can inquire heat flow and transfer, temperature differences, sun intensity, and detect the factors that affect the thermal behavior of a house. We thus explore the utility of such remote experiments for the development of student’s competences for real life situations.

The website is a competence – based concept, where students combine theory, heat flow and mechanisms of heat transfer, with actual real life concepts of this matter and deal with issues that concern contemporary architects, such as *what is a passive house*

and *which factors affect the internal temperature of those houses*. It presents the relevant phenomena without resorting too much on mathematics (Figure 2) and exposes the appropriate methods to measure the environmental parameters inside and outside a house.

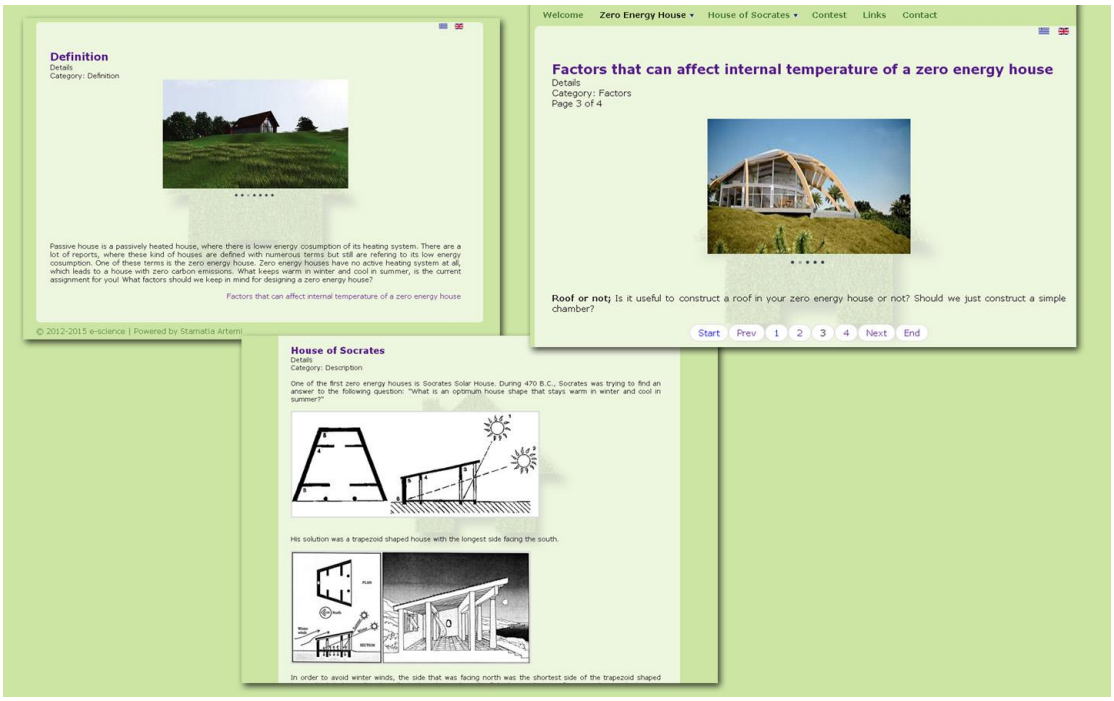

Figure 2. Introducing the passive house and the zero energy house.

A way to achieve this is through simulations (Figure 3) and three dimensional pictures, as well as useful links on the subject.

Figure 3. Exploring through simulations based on the Energy 2D simulation program (http://energy.concord.org/energy2d/) by The Concord Consortium

It also hosts the remote experiment (Figure 4) where students can acquire dynamically the environmental parameters of the model house in real time. In order to ensure real time data access, the website is based on PHP code.

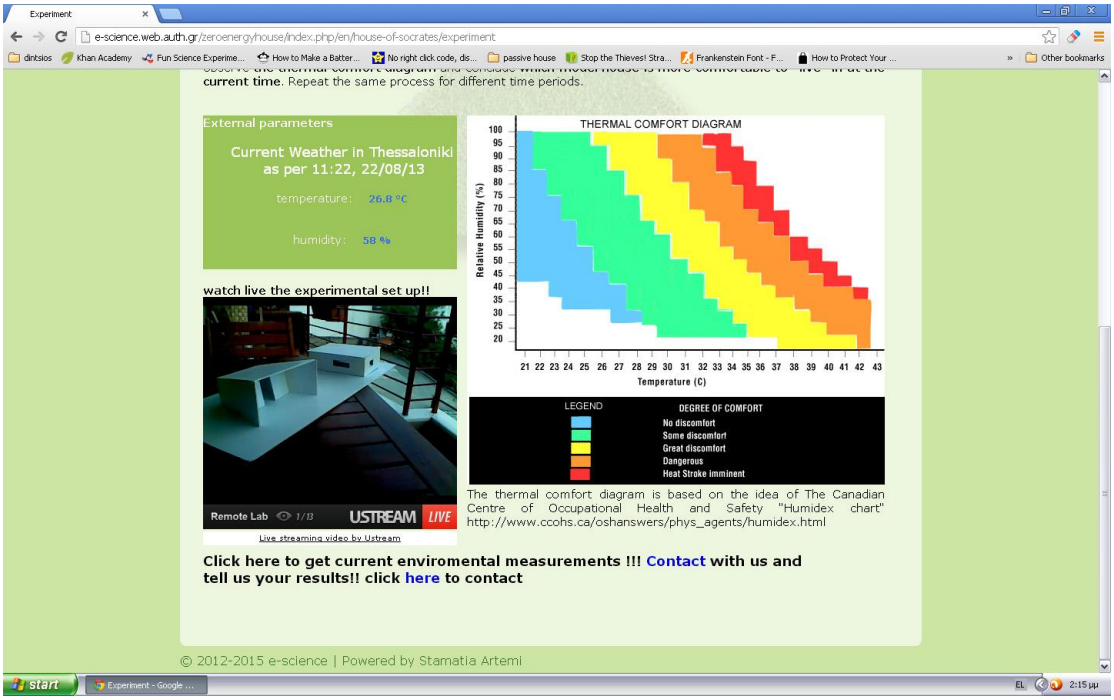

Figure 4. The remote experiment

Our experimental set up consists basically of a model house, which is exposed to ambient conditions, with appropriate sensors and configuration to measure things like the sunlight intensity, the air temperature, and the inside temperature and light intensity (Figure 5).

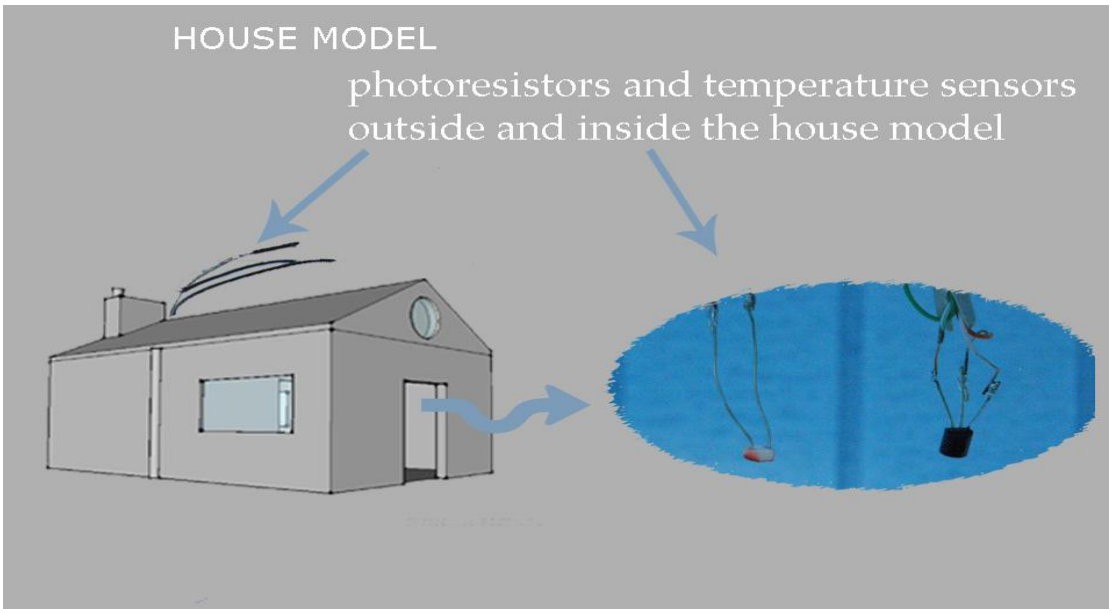

Figure 5. The experimental set up consists of a house model with temperature and light sensors.

Temperature sensors have been placed inside and outside the house model (Figure 5). Outside the house model there are two temperature sensors, one of them is exposed to direct sunlight and the other is in the shadow. This way, students will measure the temperature that the material of the sensor will reach when exposed to direct sunlight and the air temperature and understand the importance of placing correctly the experimental equipment. They will also measure the temperature difference between indoor's and outdoor's environment of the house model. By analyzing and presenting these measurements they can realize their relation and the effect of the walls. The sunlight intensity measurements can be used to determine the amount of solar energy transferred to the model house and the effect of this energy on the inside temperature. The light intensity inside the model house will determine how appropriate windows are, in supplying adequate house lighting. One can enhance these possibilities, and propose many paths of investigations, all of equal importance.

The overall present setup can be summarized in Figure 6. The sensors are connected to an Arduino board, which is connected with the server, where the measured data are stored. These data are made available to the online user through an appropriate webpage. With one click on a link, the user can obtain data at any time of the day - any day of the week.

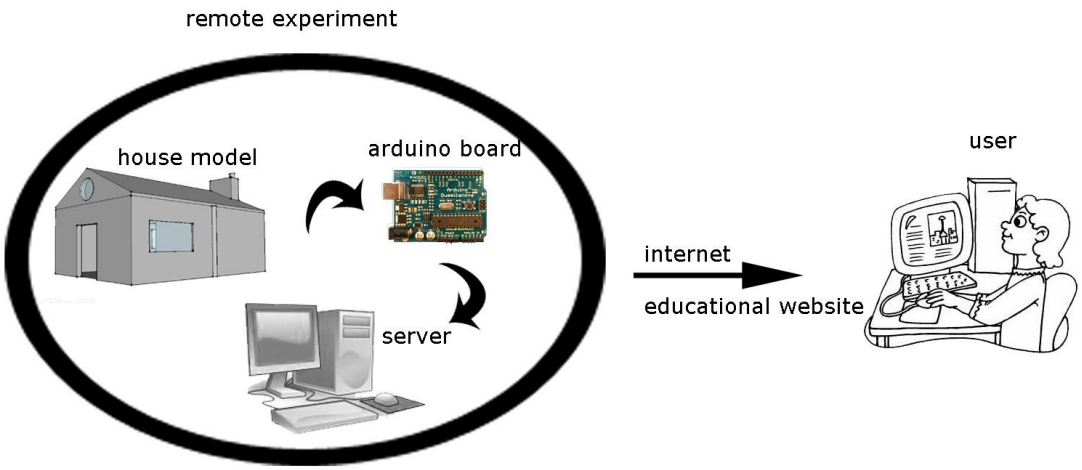

Figure 6. Schematic representation of the remote experiment.

We suggest an inquiry based approach to this subject, where students working in groups will think as scientists and decide the procedure to follow for investigating and constructing an environmental friendly passive house model. This approach encourages communication, provides the tools to analyze the data and present the results of a real experiment. The usage of the remote laboratory provides the platform to study the passive house during the daily cycle and during the different weather conditions. Because of the student–centered based teaching method that is proposed, teachers have a consulting role in the process, providing the appropriate guidance for using effectively the scientific method. This project is an extension of a successful e-learning project based on the energetic behavior of a simulated house. We have added the remote experiment to the e-learning project and set up and finished the pilot phase with a group of students from a secondary school.

COMPETENCES

There has been a lot of discussion about the type of education we want to develop for our kids nowadays. It has been pointed out that today's learning methods are still based on how kids are educated in the industrial era, where skills like following instructions for producing products as quick as possible were needed (Singer, 2000). Students should develop not just skills, but competences in various ways (physics and general), so that they can be adaptive, creative, collaborative and competitive to the twenty-first century world. 'Competences' does not mean skills (although it may include skills); it means the capacity for adaptive responses and for appropriate interpretation of information (Haste, 2009).

This educational concept was based on the above aspects of education and we believe that after completing this project students will be:

- able to apply knowledge on heat flow and its features, in practical situations.
- able to develop critical abilities, such as investigating on how energy friendly houses were designed and constructed and which procedure they should follow for developing their own house model
- capable for analyzing theory, facts and data and for combing them, such as heat transfer and factors that affect the temperature of a passive house
- creative and adaptive in order to achieve their goals in their projects (designing model houses, constructing one, suggesting alternative solutions etc)

To be more specific in physical competences, through the experimental activity that took place, we believe that students using the website's features and the remote experiment more particularly, were able to:

- perform experiments independently – actually from their own personal computers – and describe, analyze and critically evaluate experimental data
- work with a high degree of autonomy, accepting responsibility in planning and managing projects.
- understand how nature works and the numerous applications of heat flow and transfer that they could meet in their daily life, starting from heating their own food to analyze passive house's behavior.
- find physical and technical information relevant to their research
- present their results and conclusions
- get familiar with the scientific way of thinking, not just as a way of solving mathematical or physical problems, but also as a way of thinking in life in general.

CONCLUSIONS

This project is a cooperation between secondary schools and our department and will affect positively both sides: students will have the opportunity of using the equipment that university has available and researchers will have a direct feedback of the effectiveness of the specific educational approach. That's why we believe that this kind of cooperation is vital for science education research and development.

We strongly believe that students in secondary schools should not only conduct experiments in order to study qualitatively and quantitatively Physic's laws, but also to be involved in experiments that will reveal the correlation between Physics and everyday life. In this way they will comprehend that Physics are important in all aspects of daily life and will be able to understand how nature works. The whole setup can also be used in educational scenarios where students have the opportunity to integrate cognitive skills, communicating and collaborating as a part of a group for the purpose of the project, form attitudes, emotions and values concerning environmental issues and develop competences that are necessary not only as students but as future citizens of the world.

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