Enhancing the Quality of Learning by Using an Innovative Approach for Teaching Energy in Secondary Schools

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Abstract—This paper presents the results of the authors in designing, experimenting, assessing and transferring an innovative approach to energy education in secondary schools, aimed to enhance the quality of learning in terms of didactic curricula and pedagogic methods. The training is online delivered to youngsters via e-Books and portals specially designed for this purpose or by learning by doing via interactive games. An online educational methodology is available teachers.

Keywords—Education, eLearning, Energy Efficiency, Internet Methodology, Renewable Energy Sources.

I. INTRODUCTION

ELEARNING is a successful way for personal improvement which has grown in close relation with the evolution of computer usage in education [1]. Mainly because of its flexibility, more and more people from all over the world use eLearning to study a wide variety of domains. This is making eLearning one of the most attractive markets for software companies.

eLearning is also an important instrument of the "lifelong learning" concept, which encourages people to learn throughout their whole life, helping to create a knowledge-based society in which knowledge is a precondition for performance and competitiveness [2]. By individualizing the learned information and by not imposing any limitations regarding the time and location of learning, eLearning meets the requirements of a person's education according to his current phase of life and previous knowledge.

Until soon eLearning was used especially by adults who want to increase their knowledge by acquiring higher qualifications in their free time while still being employed full-time [1]. With the increase of the number of computers and the Internet's coverage, eLearning also gained a greater popularity within the younger generation. As revealed by researchers in [1], teenagers aged between 16 to 18 are very eager to use eLearning for their studies.

According to [3], [4], [5] and [6], eLearning can be defined as consisting of "communication and learning activities through computers and networks (or via electronic means)". In addition to this general definition, more specific ones exist. [7] and [8] define eLearning as the "delivery of training and education via networked interactivity and a range of other knowledge collection and distribution technologies", referring to eLearning as being "knowledge delivered by online services as education and training". The definition in [9] states that eLearning is "self-learning thorough technology". In addition to this, [9] insist on the fact that eLearning is also a collaborative type of learning.

An important part of eLearning is related to the way in which knowledge is stored and spread duties realised by using the Internet and web technologies [10]. These are included by [10] in its definition of eLearning as "the use of Internet and digital technologies to create experience that educate fellow human beings".

Children and young people are already a very important target group if we consider the number of eLearning solutions created for them, and it is considered that they will become an even more important target group in the close future. As we can easily see, the market for eLearning solutions is already a very important one and it also presents signs of improvement for the future.

Even if eLearning has already become an important part in the lifelong learning philosophy, on the whole it needs a lot of

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consolidation [2]. This situation appears because, in the case of many eLearning solutions, very important steps in their development were overlooked or badly completed due the hurry of completing the product as soon as possible and also to the lack of an initial deeper experience with the subject. The investigation of the learning and educational factors vital to develop an appropriate content is a step that is usually insufficiently considered in the development of an eLearning application or service.

From the student's point of view, it is necessary to have a simple work environment. From the instructor's point of view, it is necessary to have a tool that can be use to support teaching and also be used in grading, diminishing the time required for marking the assignments [11].

In this frame and in accordance with the EU policies, there is a priority for Romania "To remove the non technological barriers by the market formation and education", by developing:

− Campaigns at the national levels for the people education and information concerning the energy efficiency concept;
− Education and information campaigns in general and high schools, universities and even children gardens concerning the energy savings [12].

II. PROBLEM FORMULATION

Both information and education are important and cannot be separated. The *unique* approach of these projects is to engage *both students of secondary schools and their families* due to the fact that the concepts of and reasons for saving energy and using renewable energy sources are best understood through a dialogue [13].

TABLE I
TARGET GROUPS

Target Group	Proposed approach of involvement /engagement	Benefit to the target group
Students	Make them Energy Manager of their home and school and take in charge the choices concerning the use of the resources to improve the energy efficiency and the related economic saving.	Enhance their consciousness and skills
Teachers	Direct commitment in the Energy curricula and didactic approach development, management of the learning process.	Enhance their consciousness and skills
Students families	Planning of an awareness rising and mainstreaming strategy aimed to involve from the very project beginning all the stakeholders in the main issues of the project.	Improve their consciousness concerning sustainable energy education in the secondary school

The existing resources and trials are extended to cover the possible introduction of energy efficiency and renewable energy sources concepts into energy efficient homes. The global aim is to raise awareness by informing and educating teachers, students and their families so that they can do

something in their homes to save energy and help their country and the EU to reach its Kyoto targets.

The target groups are set out in Table 1.

The *Energy Education in Secondary School Methodology* used consists in three phases:

1. In the first phase of the proposed educational approach is the *design of a common set of tools* (the Energy Education in secondary school method, the Toolkit, and the Pilot action monitoring and evaluation tools and strategy) followed by *their transfer to the involved actors*.
   − *Energy Education in secondary school method* is a common guideline for teachers concerning the contents and the approach which they have to adapt to their national education framework and apply in the energy education process.
   − The *Toolkit* is a set of tools (educative modules and software instruments) which are used by the students during their work and which are transferred to them by the teachers.
   − The *Pilot action monitoring and evaluation tools and strategy* is a common evaluation framework which is applied by the teachers to evaluate if the designed curricula and didactic tools and approach are fit to achieve the foreseen objective in terms of skills and energy consciousness.
   −

2. In the second phase of the approach, the students will face the problem of *energy management of* the places where they spend their lifetime that is *school and home*. There, the students have to plan and implement interventions aimed to improve the energy efficiency. The teachers have to counsel the students and to monitor and evaluate their actions by a clear individuation of the strong and weakness points and a clear explanation of the interventions implemented and of their impact. The best way of implementing this phase is to organize a competition between students' teams.

3. The third phase, *the methodology will be assessed and spread*. At the end of the competition all the results coming from the Pilot action evaluation reports will be matched in order to identify the common criticalities and measure the impact of the actions considering the different starting points and situations (by a SWOT analysis). The final result will be *"A new approach for Energy Education in secondary school",* a manual addressed to teachers and didactic planners with the aim to innovate contents and approach of the energy education in the secondary schools.

   Last step is the peer to peer transfer of the assessed results to other students. The students will train them on energy using product, energy saving behaviors and energy managerial criteria. The teachers on the other side, will be engaged in the training of their colleagues concerning energy education contents and approach

III. PROBLEM SOLUTION

A. Educational methodology

Energy Education in secondary school methodology is a common guideline for teachers concerning the contents and the approach that will be applied during the energy education and in particular:

− *Energy curricula*: a standard plan articulated in educative modules which define the objective of the modules, the skills, know-how, and attitude that must be transferred to the students and the fittest didactic tools such as: web database, decision makers' software, self evaluation and self assessment tools. The main issues addressed will be: Energy-Using product, Energy saving behaviors, Energy Audit Method, Energy Saving Plan Designing;

− *Didactic approach*: a set of common methods aimed to enhance pro-active approach to the learning, capability to apply the skills learned in the daily life, energy consciousness, and self-evaluation aptitude.

The methodology is divided into:

− Overview and directions for the development of cognitive skills and methods of education, applicable in the context of the education in energy efficiency;

− Methods of influence (Didactics + methodology part); Description of the methods of influence, assuring the effectiveness of teaching;

− Teaching modules; Description of the teaching modules, assuring the encompassing of all major topics.

B. Educative modules

The educative modules can be available as e-Books or Handbooks accessible via Internet.

PROMES e-Book contains a set of resources and activities suitable for secondary schools. The content of the resource e-Book is presented in Fig. 1.

Fig.1 PROMES resource e-Book contents

There are a number of inter-linking themes with emphasis on understanding both the consequences of using energy, on the possible solutions to mitigating its environmental impact on global climate, and on how information that is now available can be used to apply small scale renewable sources to the home. Each lesson should be self-contained, each topic being introduced, discussed and then explored further by way of practical activities for which work sheets are provided.

Additional information is provided for teachers to assist with teaching these topics.

The e-Book comprises a *reference section* providing background information to introduce the various generic themes such as: climate change and the carbon cycle, environmental impact of energy use, impacts of global warming, saving energy in the home, and renewable energy sources.

A module section covers the following topics: heat loss, passive solar techniques, solar water heating, heat pumps, biomass for heating, wind energy, and photovoltaic cells (Fig. 2).

Fig. 2 – PV Systems

Each section of text is interspersed with practical activities to encourage learning by observation and deduction.

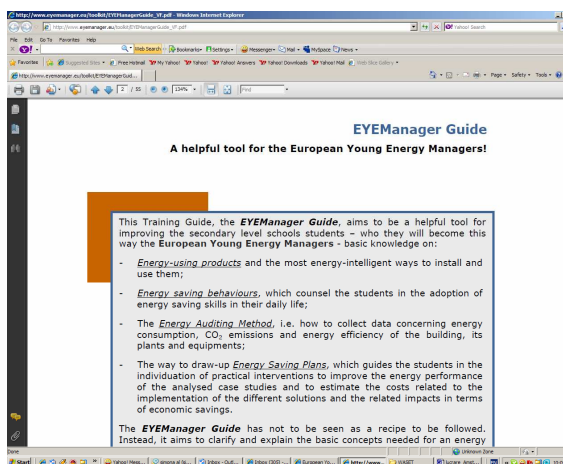*EYEManager Guide* is a practical guide accessible via internet (www.eyemanager.eu) concerning (Fig.3):

Fig. 3 EYEManager Guide

− *Energy-Using product* and the most energy-intelligent way to install and use them;

− *Energy Audit Method:* How to collect data concerning energy consumption, carbon emission, efficiency of the plants, building and equipment;

− *Energy saving behaviors* which counsels the student in the adoption of energy saving skills in their daily life;
− *Energy Saving Plan method* which guides the students in the individuation of practical intervention to improve energy performance of the analyzed case study and to estimate the cost related with the implementation of the different solutions and the related impact in terms of economic saving.

C. Interactive Games

Ecoville Game (http://ecovillelejeu.com) is an interactive game which involves building a sustainable energy community that is constrained by resource, pollution and budget limits. It is possible for individual classes to use this game being involved in a competition (an international competition which has been hold from 26 March to 26April 2008).

The Ecoville competition rewards the class that builds the town that best respects the environment (e.g. reduced energy consumption, maximum use of renewable energies, efficient waste management). The town should emit the least greenhouse gases possible while still offering the services expected of a 21st century city. The contestants should respect the commitment taken by European Union at Kyoto to reduce its greenhouse gas emissions by 8 % by on the period 2008-2012 compared to the 1990's level. The winning class is the class that best integrates the objectives of sustainable use of resources into its town. All teams taking part have to trial at least two Kyoto in the home activities. The games rules are presented in Fig. 4.
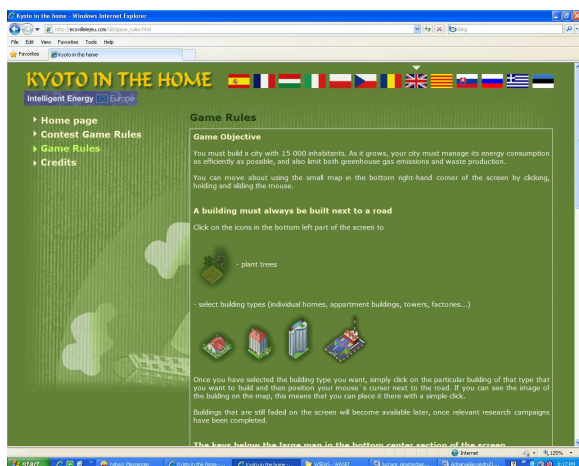

Fig. 4 Ecoville Game

Best Young Energy Manager: The EYEManager Championship is a competition in which teams composed by students from secondary schools must face the problem of energy management of the places where they spend their lifetime: school and home. Thus, EYEManager championship foresees two main phases: school management and home management,

Each phase consists in the following steps:
− *Energy audit* – students, counseled by teachers, carry out

the energetic audit of 2 schools and 2 houses with the aim to collect data from concerning: energy consumption, efficiency of the plants, building and equipment etc.;
− *Energy Audit Grid* – for each place will be fulfilled an Energy Audit Grid uploaded on the Championship Database;
− *Case study assignation* – to each team will be assigned, through a random process, 6 case studies (3 schools and 3 homes);
− *Energy Saving Plan* – each team must design the Energy Saving Plan of the assigned case study. The plan will be a combined asset of interventions on building, plants, equipments, organization and behaviors. In order to implement this plan each team will have at its own disposal a virtual budget;
− *Team Energy Wallet* – each team will have a Energy Wallet, which, step by step, gain or loss money on the base of the investment planned for structural intervention or equipment purchasing and economic saving deriving from the intervention;

Students will be supported in the plan designing by the predictive application implemented in the EYEManager software which allow to them to calculate the economic saving deriving from each intervention. The *EYEManager software* has been created in order that each team can develop the *Energy Saving Plans* of the assigned case studies and calculate the amount of money that students would subtract from their virtual budget. Due to this software, the students can study and simply understand the energy efficiency of a building and to analyze some interventions that could be done to improve it against a cost.

The software is divided into two areas:
1. Relief: allows us to define all the characteristics of the building. The students will have to collect information about: the building (location, fuel used, category, dimensions), the constructive characteristics of the heated portion of the building (constructive typology, dimensions, wall typology), walls, windows, floor, covering, heating plant, hot water production, renewable energy system and consumptions.
2. Design: is dedicated to interventions (thermal insulating, double glazing, thermal station, etc.). The students will decide the interventions between: thermal insulations on vertical surfaces and on the covering, double glazing, substitution of frames on the windows, substitution of thermal plant, assuming rules of good behaviors

As result students will know:
− Energy efficiency class that belongs to their buildings before and after interventions;
− Costs of chosen interventions;
− Energy and economic savings related to interventions.

Once focused the characteristics of the building, it is important to detect the interventions that must be done to fill all the functioning gaps of the building, in order to obtain the highest energy saving against the lowest use of economic sources and verify which is the best intervention to make:

walls caulking, floor caulking, frame substitution, intervention on the heating system, and detecting the intervention that offers the highest ratio between economic saving and the cost faced.

The team that will obtain the major economic saving to the implementation of the 6 Energy saving plans and consequently will have the richer Energy Wallet will be awarded as the Best Young Energy Mangers' Team.

IV. CONCLUSIONS

The methodological approach chosen is to make protagonist and responsible of the innovation process of the learning system its three main actors: Students, Teachers, and Families.

The fulfilled objectives have been: to improve the education offer of involved secondary schools, to enhance the consciousness and skills of the involved students concerning Energy saving, Energy-Using product, Energy saving behaviours, Energy efficiency analysis, Energy saving solutions, and to enhance the consciousness and skills of the involved teachers.

The resources that have been elaborated are comprehensive and useful and are at level which enables them to be used by both teachers and students. The holistic approach adopted to energy use provides not only an interesting science topic but also reinforces many of the concepts that students will have learnt.

The potential impacts of such approach are:

− To inform the students and empower them to realize the potential for saving energy, money, ever depleting natural resources and the environment;
− To deliver resources which link energy efficiency savings and application of small-scale RES in the home;
− To help communities locally to meet their share in the reduction of greenhouse gas emissions.

Students and their families are willing to change the way in which they view their use of energy provided that they have sufficient knowledge and understanding of why such changes are necessary. The work must be carried forward until all students in all schools throughout the EU become involved in limiting climate change through reducing environmental emissions from their homes.

REFERENCES

[1] M.P. Lau, *Online Teaching & Learning*, Nanyang SiangPau's New Century, 12 July 2003.
[2] C. Revermann, *eLearning for children and elderly people*, TAB working report No. 115, 2007.
[3] R.C. Schank, *Designing World Class E-Learning*, 1st edn., McGraw Hill, USA, 2002.
[4] Roffe, I., (2002), *E-learning: engagement, enhancement and execution*, Quality Assurance in Education, vol.10, no.1, pp. 40-50.
[5] S. Sambrook, E-learning in Small Organizations, *Education + Training*, vol.45, no.8/9, 2003, pp. 506-516.
[6] S. Tsai, P. Machado, E-learning, On-line Learning, Web-based Learning, or Distance Learning: Unveiling the Ambiguity in Current Terminology, *E-Learn Magazine, Association of Computing Machinery*, [online accessed 25 April 2003].
http://www.elearnmag.org/subpage/sub_page.cfm?section=3&list_item=6&page=1.
[7] K. Fry, *Forum focus and Overview*, *The business of E-learning: Bringing your organization in the knowledge Economy*, Telcam Group, University of Technology, Sydney, 2000.
[8] R.H. Wild, K.A. Griggs & T. Downing, A framework for e-learning as a tool for knowledge management, *Industrial Management & Data Systems*, vol.102, no.7, 2002, pp. 371-380.
[9] U. Bleimann, *Atlantis University: a new pedagogical approach beyond e-learning*, Campus-wide Information Systems, vol.21, no.5, 2004, pp. 191-195.
[10] W. Horton, Leading e-Learning, *American Society for Training and Development*, [online accessed 25 April 2003]
http://www.elearninggurus.com/articles.html.
[11] B.Bloom, *Taxonomy of Educational Objectives*, Edwards Bros., Ann Arbor, Michigan, 1956.
[12] A. Alexandru, C. Tantareanu and E. Jitaru, *Towards a Sustained Use of Renewable Energy Sources in Romania*, Proceedings of World Academy of Science, Engineering and Technology, Venice, Italy, Volume 34, octomber 29-31, 2008, ISSN: 2070-3740, pp. 1-5.
[13] A. Alexandru, E. Jitaru, R. Mayer, *Training methodologies and educational resources in the field of integration of Renewable Energy Sources in an energy efficient home*, The 6th WSEAS International Conference on Education and Educational Technology (EDU'07) – "New Horizons in Education and Educational Technology", 21-23 nov. 2007., Venice, Italy, ISBN 978-980-6766-16-9, ISSN 1790-5117, pp. 104-109.

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