Greening Dimension of Learning in Secondary Schools

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Abstract

This paper outlines the energy challenge and presents the role of education as a vector in changing behaviors related to energy consumption by adopting a sustainable attitude aimed at environmental protection. The emphasis is put on teaching activities that will enhance the capabilities of youngsters and teachers from secondary schools concerning the efficient use of energy and the promotion of Renewable Energy Sources. The authors present their results of designing, experimenting, assessing and transferring an innovative approach to energy education in secondary schools that is expected to enhance the content of curricula and to renew the pedagogical methodology. The role played by schools in a green world is strengthened by on-line training delivered to youngsters via e-books and portals specially designed for this purpose or by learning by doing via interactive games.

Keywords: energy education, climate change, energy saving, renewable energy sources, eLearning.

1 Introduction

The use of energy has increased over the centuries from the start of the industrial revolution 250 years ago to the present day use of transport and appliances. At the same time, the world's population has increased dramatic-

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ally. The result is pressure on the earth's resources, particularly fossil fuels, and the earth's ecosystems and climate.

The burning of fossil fuels results in the production of environmental emissions as well as useful forms of energy. Some of these gaseous pollutants, of which carbon dioxide is the most prolific, congregate in the upper atmosphere. These gases are termed greenhouse gases because although they allow the sunlight to penetrate the earth's atmosphere they reflect some of the retransmitted energy back towards the ground thus inducing global warming.

Observations of global temperatures dating back over the past 100 years or more indicate that the rise in global temperature of 1°C can be associated with a rise in carbon dioxide concentrations in the atmosphere. The difference with previous rises in carbon dioxide concentrations is that these changes are being induced by mankind and at a rate faster than in previous periods of climate change.

At the first "Earth" summit held in Rio de Janeiro in 1992, this impact of man was recognized and the participants agreed to sign the United Nations Framework Convention on Climate Change.

> The ultimate objective of this convention is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow eco-systems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Subsequently at a meeting of the parties in Kyoto in 1997, it was agreed to begin the task of reducing greenhouse gas emissions.

The consensus [1] is that the world's concentration of greenhouse gases has to be stabilized within five years and then decreased rapidly to limit any temperature change to 2°C. The EU and its member states have already taken action to meet their commitments under the Kyoto treaty to reduce greenhouse gas emissions and to limit this global temperature rise above the pre-industrial level; a rise of 0.7°C has already been incurred. The initial target for the EU, as a whole, is an 8% reduction in greenhouse gas emissions by 2012 although further reductions may be required; possibly up to 60% by 2050 in order to prevent a further temperature rise of more than 2°C.

Even so most, models of climate change indicate that the current rate of change will be so rapid that many species are threatened with extinction. Additionally Article 6 of the UN Framework Convention on Limiting Climate

Change calls on all parties to undertake educational activities to empower individuals to reduce their carbon emissions so there is an urgent need to initiate a change in values which should start in schools where science is taught.

There is little time left to stabilize the world's concentration of greenhouse gases without incurring irreversible changes in climate. This global impact can be minimized by local actions of mitigation and adaptation.

2 Renewable Energy Sources – A Solution for a Green World

Renewable energy sources (RES) reduce emissions, both local and greenhouse gases related and are essential contributors to the energy supply portfolio as they contribute to world energy supply security, reducing dependency on fossil fuel resources, and provide opportunities for mitigating greenhouse gases [2]. Using renewable sources generally has as result less environmental pollution and more resources available. The future strong growth of renewable energy must be part of our energy policies [3].

It is essential to limit greenhouse gas emissions so that the global earth temperature does not rise by more than 2°C above its pre industrial level. This requires the necessity of a more sustainable way of life as soon as possible. The two key steps are to use energy more efficiently and to convert from using fossil fuels to RES like wind, solar and biomass, which are non-polluting and non-limited.

At European level, the Directive 2009/28/EC unifies into a single law provisions relating to electricity, thermal (heat and cold) and transport energies produced from renewable sources, the main objective being to reach the EU27 target level of 20% energy from renewable energy sources in the final gross energy consumption and the target of 10% energy from renewable sources of energy in transport by 2020.

For Romania, the target for 2020 is provided for by Directive 2009/28/EC and is 24% renewable energy in the gross final energy consumption, an increase of 6.2% compared to the reference year 2005 (reference value for 2005 is 17.8%).

Promoting renewable energy capitalization (RES) was one of the priority objectives of energy policy, the Romanian strategy of valorization of RES, adopted in 2003, defining the following objectives: integration of RES into the national energy system, the diminish of technical-functional and psycho-

social barriers for RES valorization, simultaneously with the assurance of economic competitivity, promotion of the private investments, energy supply of isolated places by using the local RES potential and facilitation of the participation of Romania in EU market of "Green certificates" for energy from RES [4].

The "Energy Strategy of Romania for 2007–2020", approved by Government Decision 1069/2007, established the national indicative targets for the share of electricity produced from renewable energy sources in gross internal consumption of electricity in the years 2010, 2015, 2020, respectively 33, 35 and 38%.

3 Education for Sustainable Development

Resource depletion, environmental pollution, global warming and climate change are interrelated and interdependent phenomena. Whilst the earth's population was small and energy use was less, the impact of humans on the natural eco systems was small. Now that energy usage has increased, that impact is much greater and, as already discussed, is non-sustainable, not for even one more generation. Attitudes toward the use of energy must change and there is a need to value energy as something, which is both scarce and precious.

At the second "Earth" summit in Johannesburg in 2002, it was agreed that there was an urgent need to inform and educate persons about ways of adapting to more sustainable life styles and UNESCO has declared the decade from 2005 to 2015 the decade of Education for Sustainable Development (or ESD).

All European educational and environmental ministers, following the UNECE Kiev declaration of 2003, have adopted the education for sustainable development. Fundamental to limiting climate change, innovative educational ideas and processes are required throughout the life long learning process.

Andris Piebalgs, European Commissioner for Energy underlines in "EU energy policy: Towards a third industrial revolution" the importance of education for sustainable energy, that is clean, and that provides us long-term energy security and a very large degree of energy independence. It would need to catalyze changes in education, research, and the development of our cities. There are many grounds to believe that such a commitment would be truly welcomed by Europe's citizens, particularly the younger generation that will have to inherit the consequences of today's decisions [5].

Youngsters are a significant consumer group of energy, and they have important potential influence on the energy consumption of today and the future. The behavior changes and the application of energy saving plan could ensure an important economic saving, which should be reinvested in innovative learning facilities or international meetings. Secondary schools averagely consume 194 kWh of energy per year, emitting 110.93 Kg of carbon and spending £32.40 per pupil [4]. It is estimated that schools engaging on simple energy management programmes can save between 20–25% on their average consumption [6].

4 eLearning – A Possible Solution?

ELearning is a successful way for personal improvement, which has grown in close relation with the evolution of computer usage in education [7]. 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 [8–10] 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".

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 [7], teenagers aged between 16 to 18 are very eager to use eLearning for their studies.

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.

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 [11].

5 A New Pedagogical Approach for a Green World

For the purpose of holistically limiting climate change, a pedagogical approach is required in which the teacher encourages his students to carry out evidence-based argumentation. When a consensus is reached by embodying several different viewpoints, science lessons become more interesting and students collaborate, encouraging social cohesion. By using a pedagogical strategy, teachers and students reflect on the causes to climate change and discuss local solutions to reducing their carbon footprint so that the existing biodiversity is maintained.

The result of the pedagogical approach is to initiate local actions leading to a more sustainable use of energy and a limitation of climate change by individuals and communities.

As the concepts and motivation for saving energy and using renewable energy are best to be discussed, secondary school students, teachers and their families are all engaged for information and education purposes in a dialogue [12]. The purpose of this dialogue is that of raising awareness so that secondary school students, teachers and their families take action to save energy in their homes so that they help their country and the EU to reach their Kyoto targets.

The target groups are set out in Table 1. Schools must include education on sustainable development, with climate change as the most important topic, into their lesson plans. This can be divided into:

- The decision on appropriate resources for the teaching of such multidisciplinary subjects.
- The development of teaching and learning strategies for making the subject more interesting and relevant to students' lifestyle. item The raising of awareness regarding the importance of sustainably using energy for preserving life on earth.

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

1. In the first phase of the proposed educational approach, *a common set of tools is designed and they are transferred to the actors involved* (see Table 1).

Table 1 Target groups

Target Group	Proposed approach of involvement/ engagement	Benefit to the target group
Students	Make them Energy Managers of their home and school and give them responsibility of the choices concerning the use of resources for improving energy efficiency, the related economic saving and for promoting the use of RES in their homes	Enhance their consciousness and skills
Teachers	Direct commitment in the Energy curricula and didactic approach development, the management of the learning process	Enhance their consciousness and skills
Students families	Planning of an awareness rising and mainstreaming strategy aimed to involve all the stakeholders	Improve their consciousness concerning sustainable energy education in the secondary school

2. In the second phase, the students will practice *energy management in their towns, schools and homes* and learn as part of this process. Students are best involved in this phase by participating to competitions as being divided in teams.
3. In the third phase, "A new approach for Energy Education in secondary school", the results obtained from the student competition and the outcomes of the taken actions will be used to assess and spread the methodology.

5.1 Design of a Common Set of Tools Proposed for the Educational Approach

The common set of tools for the educational approach consists of [13]:

A The *Energy education in secondary school method* contains a common guideline for teachers regarding the approach and contents. Teachers need to adapt the approach so that it is applicable in their national educational framework.

B The *Toolkit* is a set of tools (educative modules and software instruments) that students will use and which can be transferred to them by teachers or as an eLearning facility.

C The *Pilot action monitoring and evaluation tools and strategy* form a common evaluation framework used by teachers to test if the designed curricula and teaching tools and approach are appropriate for achieving the wanted objectives in terms of skills and energy awareness.

(A) The *Energy education in secondary school method* is a guideline for teachers referring to the way energy education will be carried out in secondary schools so that students become empowered to decide how to effectively use it. It contains:

- The Energy curricula: a standard plan consisting of educative modules (energy-using product, energy-saving behaviors, the use of RES in the home, energy audit method, energy-saving plan designing), which must be transferred by teachers to their students and the didactic tools needed for this purpose such as web databases, self evaluation and self assessment tools, decision makers' software.
- The Didactic approach: a set of common methods aimed at enhancing learning by doing, promoting eLearning to students, giving them the capability to apply their experience from day-to-day life, gain energy consciousness and the skill of self-assessment.

The main objectives of this methodological manual are to make the information more clear and accessible to the students and to insist that they implement what they have learned in real life. The principles of the methodology are the balance between learning by doing and learning through sense and the focus on the practical value and the rational use of the information for problem solving in specific situations.

(B) *The Toolkit*

(B1) *Educative modules* can be available on paper or as on-line e-books or handbooks.

(a) The *PROMES e-book* [14] consists of resources and activities especially designed for secondary schools. The contents of the e-book resource are provided in Figure 1. It begins with the introduction of various generic themes such as: climate change and the carbon cycle, the impact of energy use on the environment, the impact of global warming, saving energy in the home, and renewable energy sources.

A number of inter-linking topics are afterwards developed with a focus on understanding the negative effects of using energy, the

CONTENTS

1. Sustainable use of energy
2. Energy efficiency in the home
3. Renewable energy sources
4. Heat flow in buildings
5. Passive solar
6. Solar water heating
7. Heat pump systems
8. Biomass
9. Wind energy
10. Photovoltaic systems

Figure 1 PROMES resource e-book contents



Figure 2 PV systems

possible solutions to reducing its impact on the environment and how to apply small-scale renewable energy sources in the home (Figure 2).

Each lesson first introduces the topic, discusses it and then explores it further by means of practical activities provided on activity sheets. The practical activities encourage students to learn by observing and deduction.

Extra information assists teachers in the teaching of these topics.

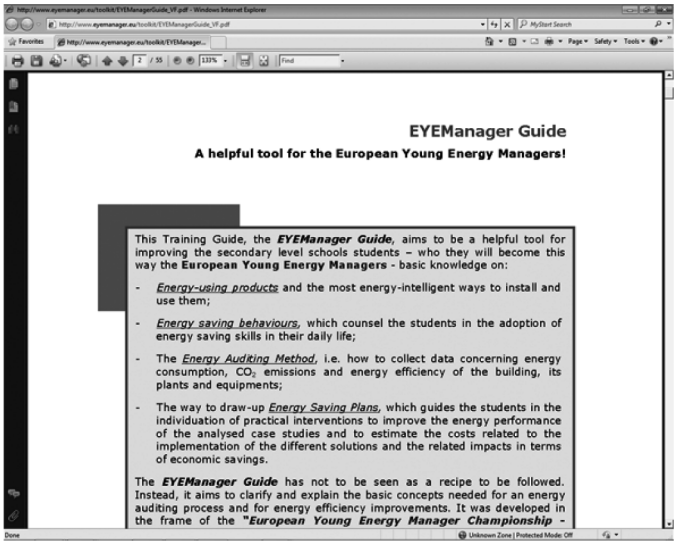

Figure 3 EYEManager guide

(b) The *EYEManager Guide* is an online practical guide (www.eyemanager.eu) [13] (Figure 3) and concerns:

- ∗ Energy-using products and the most energy-intelligent way to install and use them.
- ∗ Energy-saving behaviors which counsels the students on the energy-saving behavior they can adopt in their everyday life.
- ∗ Energy audit method: How to collect data regarding energy consumption, carbon emissions, plant, building and equipment efficiency.
- ∗ Energy-saving plan method which guides the students in initiating practical interventions for improving energy performance in a case study, in calculating the costs and related economic impact in terms of economic saving which are related to each solution.

(B2) *Software instruments*

The EYEManager software was designed in order to discuss and understand a building's energy efficiency and analyzes the possible solutions for improving it against the costs. This software allows the student teams to develop the Energy Saving Plans related to the case studies and es-

timate the monetary costs that students would use from their virtual budget.

The software defines building characteristics and the appropriate interventions based on rules of good behaviors (thermal insulating, double glazing, thermal station, etc.). It is possible to display the costs related to each intervention and the outcomes of the chosen interventions in what concerns economic savings, costs and energy savings.

(C) *The pilot action monitoring and evaluation tools and strategy*
The pilot action monitoring and evaluation tools and strategy is a common monitoring and evaluation framework defined in terms of approach, tools and indicators which evaluate the pilot implementation' s strong and weak points. The aim is to decide if the designed curricula, didactic tools and approach are appropriate for achieving the wanted objectives in what concerns the skills and consciousness improvement. Questionnaires concerning the efficient use of energy and the consideration of RES are administered to the students, teachers, students' parents and stakeholders involved in the educational process.

The questionnaires first evaluate the knowledge about energy and the students' attitudes regarding environmental topics. Results for 191 students (96 girls and 95 boys) from 9 European countries showed that students replied to 73% of the questions correctly. The final test showed that 96% of the students provided more than 50% correct answers.

The tests also show that regarding attitude, 65% of the students strongly agree that energy is very important from an environmental perspective.

The questionnaire for stakeholders aimed to capture for example if the activities were interesting and 96% of the participants agreed or strongly agreed. The main group of participants consisted of parents, representing 58% of the total. Other groups consisted of teachers (17%), politicians (12%), didactic planners, municipality officers, journalists and others.

5.2 Energy Management in Students' Towns, Schools and Homes

5.2.1 Ecoville Game

The *Ecoville Game* (http://ecovillelejeu.com) is an interactive game with the aim of building a sustainable energy town that is constrained by resources, pollution and budget limits. The players are expected to respect the Kyoto European Union commitment, which requires that countries reduce their greenhouse gas emissions by 8% between the years 2008–2012 as compared



Figure 4 The Ecoville Game

to their 1990s level. It is possible for individual classes to play this game by participating in a competition (the first international competition was held from the 26 March to 26 April 2008).

Within an Ecoville competition, the team that best protects the environment (e.g. by saving energy, using renewable energy sources as much as possible, and doing efficient waste management) wins. The developed town should emit as little greenhouse gasses as possible, while still offering all the 21st century services to its citizens.

Figure 4 shows the game rules.

5.2.2 Best Young Energy Manager

The EYEManager Championship is a competition in which teams composed of secondary school students must manage the energy consumption of the places where they spend their life: school and home. The choice to build international teams composed by youngsters coming from several European countries answers to the need to favor the collaboration among students and to give them the opportunity to face energy issues in different contexts.

The EYEManager championship consists of five phases:

Phase 1: *International teams' composition*. After the energy training organized by the involved schools in the project, each selected class was divided in groups, which formed parts of the international teams.

Phase 2: *Schools and houses energy audits*. This phase implemented in the following individual steps:

1. Definition of the premises to be audited: 2 schools and 2 houses in each of the European countries participating in the project will be analyzed;
2. Energy audit: The students, counseled by expert technicians, carried out the energy audit of the different places/objects of intervention, with the aim to collect data concerning the energy consumption, as well as the efficiency of the buildings, their plants and the rest of equipment used.
3. Energy audit form: For each one of the audited places, an Energy Audit Form (else "Grid"), downloadable from the EYEManager Championship Database, has to be filled in by each of the "class/country groups".

Phase 3: *EYEManager championship's case studies assignation*. The "case studies" was assigned to each one of the international teams by using a "ballot procedure" by drawing from the ballot-box for schools the three cases that will be assigned to each one of the international teams and from the houses' ballot-box the relevant three house cases per team.

Phase 4: *Schools and houses energy management*. The key aspects of this phase are the following:

1. Energy saving plans of the assigned case studies: A combined asset of interventions on the building, plants, equipments, behaviours, etc.
2. Team energy wallet: Each team will possess an energy wallet, which, step by step, will gain or lose money on the base of the investment planned for any structural intervention or equipment purchasing on the one hand, and the economic savings deriving from the intervention on the other.

Students will be supported in the preparation of their plans by a predictive application included in the EYEManager Championship software, which will allow them to calculate the economic savings deriving from each one of the proposed interventions.

Phase 5: EYEManager Championship Award Ceremony. The winner is the international team that will obtain the major economic savings to the implementation of the energy saving plans, i.e. the team that will have "richest"

energy wallet at the end of the competition, will be awarded as the Best European Young Energy Managers' Team.

5.3 A New Approach to Energy Education in Secondary Schools

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 on the base of the different starting points and situations. The SWOT analysis results will provide the basic data for the assessment and fine-tuning of the tools designed in the framework of the Energy Education in secondary school method and Toolkit.

The design of a new approach for Energy Education in secondary school, a manual addressed to teachers and didactic planners with the aim to innovate the contents and the approach to energy education in secondary schools, has been realized thanks to the results of the Pilot Action Evaluation Report made by Energy Agencies, teachers and students.

6 Conclusions

Students, teachers, and families are the three main actors in the methodological approach presented in the paper. They are protagonists and responsible for the innovation process of the learning system in the energy domain.

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 behaviors, 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 to both teachers and students, can link cause and effect and suggest actions which enable energy to be used more efficiently and introduce non-polluting sources of energy. These resources make science more interesting and relevant to everyday life. The teachers are assisted to develop multi-disciplinary skills for translating cognitive teaching into realizable actions. The resources will thus encourage and stimulate European approaches to a topic with global impact. By linking cause and effect, the students and school are encouraged to initiate local action, which will mitigate the environmental impact of climate change and facilitate adaptation.

The humanistic approach to science education is selecting topics, which are meaningful to students' current and future life and occupation. A ma-

jor topic is global warming which will increasingly affect their lives. The challenge for teachers is to engage students to explore how switching to sustainable sources of energy and using energy more efficiently can reverse this trend. This illustrates how science impacts human values and actions.

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References

[1] IPCC Fourth Assessment Report: Climate Change, 2007. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1.

[2] International Energy Agency. Renewables in Global Energy Supply. An IEA Fact Sheet, January, 2007. Available: http://www.iea.org/textbase/papers/2006/renewable factsheet.pdf.

[3] A. Piebalgs. Preface to the European Renewable Energy Policy Conference, Brussels, 29–31 January 2007. Available: http://www.bmu.de/files/pdfs/allgemein/application/pdf/reconference_programm.pdf.

[4] A. Alexandru, G. Gorghiu, Elena Jitaru, Monica Pârvan. Energy efficiency in the frame of Kyoto's targets. In *Proceedings of the National Conference New and Renewable Energy Sources*, Section IX: Energy Quality and Ecology, Bibliotheca Publishing House, Târgovişte, pp. 410-413, 2003.

[5] Andris Piebalgs. EU energy policy: Towards a third industrial revolution. http://www.euractiv.com/en/energy/eu-energy-policy-third-industrial-revolution/article-180372.

[6] DfES/DEFRA. Energy services for schools, http://www.teachernet.gov.uk/_doc/2777/es-schools.pdf.

[7] M.P. Lau. Online teaching & learning, Nanyang SiangPau's New Century, 12 July 2003.

[8] C. Revermann. eLearning for children and elderly people, TAB Working Report No. 115, 2007.

[9] 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.

[10] R.H. Wild, K.A. Griggs and T. Downing. A framework for e-learning as a tool for knowledge management. *Industrial Management & Data Systems*, 102(7):371–380, 2002.

[11] A. Alexandru, C. Tantareanu and E. Jitaru. Towards a sustained use of renevable energy sources in Romania. In *Proceedings of World Academy of Science, Engineering and Technology*, Venice, Italy, October 29–31, Volume 34, pp. 1–5, 2008.

[12] A. Alexandru, E. Jitaru and R. Mayer. Training methodologies and educational resources in the field of integration of Renewable Energy Sources in an energy efficient home. In *Proceedings of the 6th WSEAS International Conference on Education and Educational Technology (EDU'07) - New Horizons in Education and Educational Technology*, Venice, Italy, 21–23 November, pp. 104–109, 2007.

[13] A. Alexandru, O. Bica, E. Tudora, C.S. Alecu, C.A. Alexandru and I. Covalcic. Enhancing the quality of learning by using an innovative approach for teaching energy in secondary schools. In *ICACSE 2010: International Conference on Applied Computer Science and Engineering, Proceedings of World Academy of Science, Engineering and Technology (WASET)*, Year 6, Issue 70, Amsterdam, The Netherlands, September 28–30, 2010, 2010.

[14] A. Alexandru, E. Jitaru and C.A. Alexandru. *Energy and Environment*, Bibliotheca Printing House, Târgovişte, 2007.

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