Energy Policy 36 (2008) 3226–3232

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Effective education for energy efficiency

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ARTICLE INFO

Article history:
Received 23 February 2008
Accepted 22 April 2008
Available online 20 June 2008

Keywords:
Energy-saving awareness
Energy education
Renewable energy education

ABSTRACT

A lot of today's world vices can be eliminated if certain targeted modules and adapted curricula are introduced in the schooling system. One of these vices is energy squandering with all its negative consequences for the planet (e.g. depletion of finite energy sources and the subsequent climate change). This paper describes the results of an energy-thrift information and education project taking place in different levels of education in Crete—Greece, which records 321 students' and their parents' routine energy-related behavior and proves that this behavior changes to a more energy efficient one, after the dissemination of relevant information and the participation into the energy education projects. Namely, response percentages indicating the energy-efficient behavior increased after project participation while the ones indicating an energy-squandering behavior decreased. The Wilcoxon signed rank test was statistically significant in all energy behavior questions related to students and to most questions related to parents.

1. Introduction

Climate change caused by anthropogenic emissions of greenhouse gases, mainly from the use of fossil energy, needs to be tackled effectively and urgently. The Kyoto Protocol in the United Nations Framework Convention on climate change strengthens the international response to climate change. Developed countries committed themselves to reducing their collective emissions of six key greenhouse gases by at least 5% by the period 2008–2012. On March 2007, the European Council set up the energy and climate change-related objectives: reduction of greenhouse gas emissions by 20%, integration by 20% of renewable energy sources into the final energy mix in the EU and reduction by 20% of EU primary energy use by 2020. The transition to a low carbon economy will take decades to implement and concerns every sector of the economy. Improving energy efficiency is a priority for EU energy policy and demands not only efficient technologies but also energy saving through changes in consumer awareness and behavior.

Greece is obliged to have 18% renewable energy in the final energy demand by 2020, save each year 1% more energy till 2020 and reduce the CO_2 emissions by 4% in 2020 (Commission of the European Communities, 2008). Unfortunately, the growth of renewable electricity in Greece is slow (Tsoutsos et al., 2007) although there is a high private initiative (Maria and Tsoutsos, 2004). The potential for energy efficiency improvements in Greece is large because energy intensity (total energy consumption divided by Gross Domestic Product) is 203 toe/MEUR'2000, higher than the majority of the European countries, which is on average 185 toe/MEUR'2000 (Greece-Energy Mix Fact Sheet, 2007). This is also due to the absence of continuous, targeted and organized energy-saving campaigns coupled with the fairly inexistent "energy-saving culture".

Lack of energy knowledge is regarded as illiteracy, innumeracy and apathy according to Newborough and Probert (1994). A lot of emphasis is being laid nowadays on the systematic and organized information of pupils on energy saving and renewable energy attitudes. Raising young people's awareness on these matters promises and secures the existence of energy responsible consumers in the future. Agenda 21 suggests that all students and their teachers should be exposed to concepts and methods of ecologically sustainable development as part of their formal education (UNCED, 1992). The role school plays is fundamental for the success of this endeavor coupled with the fact that energy awareness is basically formulated during the childhood (CRES, 2008). Furthermore, children are more receptive to new concepts and can act as educational agents (Dias et al., 2004) and opinion leaders at home and also grow as environmental conscious citizens (Managenergy, 2004).

Education can play a pivotal role in instilling energy thrift and efficient behavior and attitudes in society (Zografakis et al, 2007). Early enough, Ellis and Gaskell (1978) had reported a strong link

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doi:10.1016/j.enpol.2008.04.021

between an individual's level of education attainment and the likelihood of his/her adopting energy-thrift measures and accepting the need for interventionist government policies to encourage the more rational use of energy. "Energy squandering could be better remedied by education and legislation rather than advanced technological solutions. The probability of achieving a sustainable future increases with the energy literacy of our society" (Newborough and Probert, 1994). United Nations (UN, 2005) state that "education in addition to being a human right, is a prerequisite for achieving sustainable development and an essential tool for good governance, informed decision-making and the promotion of democracy. Therefore, education for sustainable development strengthens the capacity of individuals to make judgments and choices in favor of sustainable development". As a result of this, energy studies are rapidly emerging as a new discipline (Jennings and Lund, 2001) and can be classified into two types of energy education (Newborough et al., 1991): one which focuses on developing energy professionals and another which aims at producing a more energy-literate society via compulsory primary and secondary education. This paper is concerned with the latter type of studies.

Barriers to the energy economy are multiple: institutional, market, organizational and behavioral ones (Weber, 1997). Manufacturers could be encouraged by market forces to develop less energy squandering technologies that will save money to consumers and make them demand energy-efficient technologies. However, energy-related education is a macro-level tool, since it is provided centrally, and solves the rest of the above-mentioned aspects of the problem. Fig. 1 depicts how this education mechanism could work. The flowchart shows that there is central intervention in the school curriculum set-up, e.g. through an energy information project. In the context of the current project the pupil is involved in the education process, who in turn passes part of the information to his/her parents of the everyday knowledge he/she gets from school. Therefore, the introduction of an official school module would seem necessary because according to the results presented in this paper, it is effective.

An Environmentally Responsible Citizen (ERC) is one with awareness, interest, participation and capability to understand and solve environmental problems (Hungerford and Volk, 1990). Theories about the development of ERC focus mainly on the correlation of its determinants. Two main approaches can be discerned in this context: One is the model of Environmentally Responsible Behavior (ERB) developed by Hines et al. (1987). According to it, the ERB is formed by the intention to take action (determined in turn, by knowledge, capabilities, personality and the actions at hand that can solve the problem). The second model is the one of behavior flow by Hungerford and Volk (1990). It consists of primary and secondary variables. The former encompass environmental awareness and sensitivity, ecological knowledge, the "psychological gender", attitudes towards pollution, technology, economy and the degree to which the individual regards environmental problems as his/her own problems. The latter group consists of the knowledge of the consequences of his/her actions, personal commitment to solving the problems, people's confidence in being able to solve environmental problems and the strength people derive from solving them.

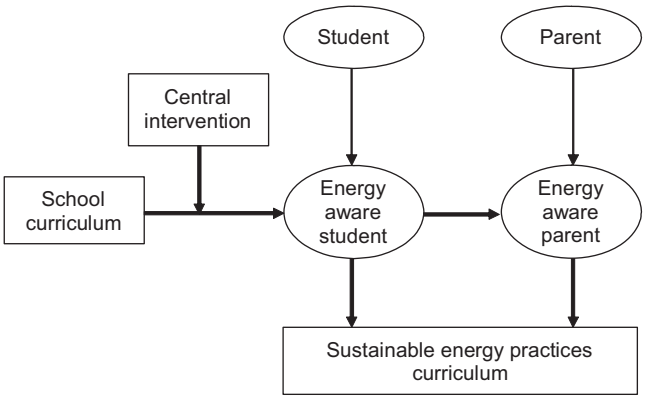

Fig. 1. The effects of energy related education in society.

Last but not least, Ajzen (1991), in his theory of planned behavior, underlines that behavior is not a result only of one's will, because there might be some exogenous control on this will.

With respect to the above short literature review, we need to stress the following points as regards our piece of research: Through the questionnaire and the annual education process, the respondent realizes the existence of some easy actions that can make him/her more energy efficient. Also, he/she realizes that he/she has a lot of power in his/her hands to solve the problem and this stems from some minor and costless corrections that he can make in his everyday life. Furthermore, participation in the education and information process raises his awareness, knowledge, attitudes and confidence that he/she can seriously affect the solution of the energy problem in a positive way. All these parameters (according to above-mentioned literature) shape the environmental responsible behavior. Therefore, the described project produces a learning and changing behavior effect for people participating in it.

The European Commission recognizes that educational activities are a vital part of raising awareness on sustainable energy issues. Thus, it has a role in developing activities in this area that enable dissemination of existing information and programmes and promoting best practices (Commission of the European Communities, 2006).

Priority number eight of the Commission's recently adopted Energy Efficiency Action Plan calls for raising awareness on energy efficiency (Commission of the European Communities, 2006). The European Commission has financed many energy education projects mainly under the "Intelligent Energy Europe" program. Such actions financed by EU are "The persuasive power of children towards energy consumption in the local community" project (FEE, 2008), Force for Energy by Children through Education (FEEDU, 2007), Kids4Future (Kids4Future, 2008), Energy path (Energy path, 2008), Active learning (Active learning, 2008) and many others. Moreover, energy educational activities and projects have been implemented in the context of other European programs such as Comenius (School education), Erasmus (higher education), Grudving (Adult education and other education pathways) and Minerva (information and communication technologies in education).

The Regional Energy Agency of Crete has been involved in environment-energy educational projects in schools since 1997 (FEE, 2008; FEEDU, 2007). The results of the above initiatives have been very successful and have been widely disseminated not only to the rest of the schools in the island of Crete but also to many other schools in Greece.

However, although numerous energy education and information projects are currently taking place in Europe, little research has been done in the investigation of their success (Bjørnå and Dyhr-Mikkelsen, 2003). Herein lies the novelty of this paper. It proves and quantifies the information effects of a targeted education venture in primary and secondary education in Crete, Greece. The methodologies, the educational tools used and the assessment procedures have been jointly developed and implemented with partners from many European countries. Therefore, this piece of research is of major interest to all European member states and to any other country outside European Union with

similar energy education systems. This educational project was launched by the Regional Energy Agency of Crete, aiming to measure energy-spending behavior of schoolchildren and their families and to teach energy-saving behavior. Results from this research will be useful for the establishment of a regional and national energy-spending and -saving map and policy-making.

The rest of this paper is organized as follows; Section 2 provides the education materials, Section 3 describes the methodology, Section 4 provides the data, analysis method and results, Section 5 provides the discussion, while Section 6 is the conclusion.

2. Education materials

Usually the typical school curriculum provides a few energy lessons in the physics module. However, education provided by this module does not have the character an information project assumes. Education provided in these projects is targeted at teachers, students and their parents on the following matters: acquisition of energy and environment awareness, renewable energy familiarization, rational energy usage and viable mobility (means of transport). The project content could also consist of laboratory classes, field visits, energy-efficient measures at school, simple installations using renewables at school, energy audits and monitoring of energy consumption of the school, hands-on approaches, quantification of effects such as avoided greenhouse gas emissions (Managenergy, 2004).

The project, whose results are presented and analyzed in this paper encompassed: education and inducement through information and hands on experiences, the realization of special information session series for teachers, as well as the evaluation and dissemination of relevant teaching experiences and educational programs related to environmental administration, energy saving, renewable energy sources and the relationship energy-environment. Project-based learning drives children to analyze the situation, search for answers and solutions. Thus, the school is bringing in the reality of society. This active attitude works well to motivate children, even those who are not the best of the class (Managenergy, 2004).

In more detail, materials used encompassed: special information material on energy matters addressed to teachers, application and teaching tools such as an education kit with audiovisual material, books and transparencies, local application examples of renewable energy and energy saving; special teaching material for pupils with theory and games, exercises and drawings, so that they would learn about renewable energy in an interactive and congenial way; information and reminder material was distributed at schools (brochures, mouse pads, pencil-cases, pencils, wall pictures, posters, notebook stickers, wooden toy helicopters with photovoltaic systems and small wind turbines); lessons were given in all participating schools with active pupil involvement; visits of school classes took place in renewable and conventional energy production units; a drawings exhibition took place hosting drawings and other artistic forms that students had manufactured. Games with an energy and environmental character (theater plays, happenings, songs and collective drawings) took place at the exhibition venue, in which young visitors participated with enthusiasm. A specific collective game in a surface of 50 m^2 (the so-called Energy Goose game was specifically created by the Regional Energy Agency of Crete with the cooperation of experts) was also highly appreciated and used by the pupils. Moreover, this event was highly publicized in local press and TV. Last but not least, the questionnaire surveys presented in this paper are part of the information campaign and explain the energy information effects in a tangible manner.

After the completion of the questionnaire in class, pupils had to take it home and ask their parents to fill in their own part of the questionnaire. "The importance of personal contact between information agents and users is recognized as much more efficient in disseminating the appropriate information, influencing people's attitudes and persuading them to act, juxtaposed to written or mass-mediated information" (Vedung, 1999).

Information in our questionnaire is very specific, shows which measures are profitable for the individual and how they should be undertaken. Vedung (1999) on the other hand, suggests an unusual information way, the so-called feedback, which consists in people getting high-quality information about how much energy they are already using by the hour, even the minute or second, instead of telling them what the correct thing to do is.

3. Methodology

Greek schooling system consists of the nursery school, primary school, junior high school and senior high school. Table 1 shows the pupil ages corresponding to each school level, the participation status and the number of classes (years) contained in each level. The survey was launched in three levels of Greek schooling in a common form; five last classes of primary school, all three junior high school and the first two classes of the senior high school. The sample was representative of the total number of students because they came from schools of a variety of geographical areas (urban and agricultural) and society income levels (state and private schools) all over the island.

An executive from the Regional Energy Agency of Crete visited the participating schools at the beginning of the academic year 2006–2007. She made an introduction on energy topics and a presentation of the project to both pupils and teachers. Afterwards and throughout the academic year, teachers would serve as administrators. "They were preferred to mere professionals for this job, because children would consider the professionals' visit as time off. Teachers are the most effective multiplier to reach the students and a way of making the actions live in the school" (Managenergy, 2004). Pupils had to anonymously fill in a fully structured questionnaire before and after a series of energy information lessons were given during the academic year. First filling in served to merely record their raw attitudes at the beginning of the academic year (phase A). Second filling in took place in the end of the academic year and it aimed to find out whether and to which direction these attitudes had changed after the knowledge uptake throughout the year (phase B). In both phases pupils filled in the questionnaires anonymously and independently with no influence from their teachers or peers. Immediately afterwards (in each phase), they were asked to take questionnaires home for their parents to fill in. The completed questionnaires were assigned reference code numbers (instead of pupils' names) and were sent for analysis to the Regional Energy Agency of Crete. In the end of the school year, new identical questionnaires were completed by pupils and their parents and were sent to the Regional Energy Agency of Crete for association with their first counterparts and further analysis. Neither pupils

Table 1
Greek schooling system map

School type	Age	Participation status	Classes/years in this level
Nursery school	4	Optional	1
	5	Compulsory	1
Primary school	6–12	Compulsory	6
Junior high school	13–15	Compulsory	3
Senior high school	16–18	Optional	3

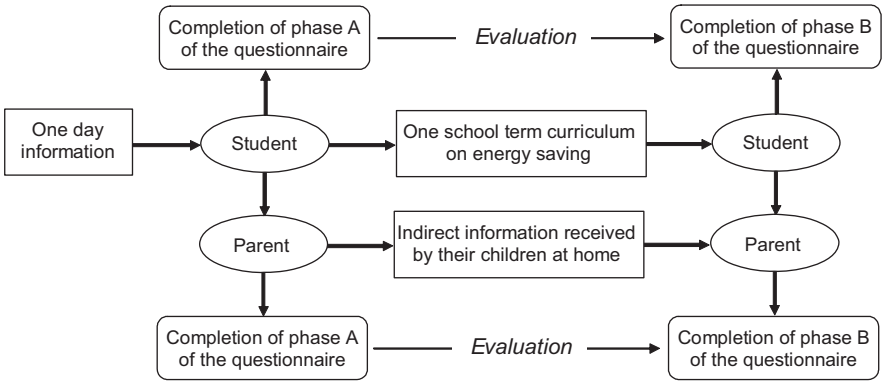

Fig. 2. The effects of energy related education in the current project.

nor parents could see their answers in the first questionnaire. Each questionnaire consisted of three parts: the first part contained questions for pupils, the second contained questions for parents or guardians and a third part contained mostly demographic questions such as gender, class, school name and parents' income. The methodology scenario is depicted in Fig. 2.

Questions were very specific and aimed at finding whether a particular energy-thrift behavior occurred or not and at what level. At the same time questions had an informative character on what the politically correct energy-thrift behavior is and how to achieve reductions in energy use. Therefore, questions can be regarded as stating or evoking energy-friendly attitudes. They are questions but at the same time they are statements of an energy wise person. They concentrate on the following topics: the use of electrical appliances at home, space temperature adjustment at home, the water consumption, transportation, space temperature adjustment in school, the rational use of heating installations, apparatus in school and recycling. Furthermore, questions can be divided in 2 broad types: one is questions about activities directly related to energy consumption (e.g. turn off the stand by button of the TV set) and another one with questions indirectly related to energy consumption (e.g. do you leave your room window wide-open for a few minutes for the air to be renewed?).

4. Data and results

The survey comprised 321 pupils (number of valid questionnaires) ranging from 2nd primary to 2nd senior high school), encompassing 10 education level-classes and 321 parents (Cretan population is 594,368, census 2001). 53% of the pupils were female and 47% male. As regards parents' survey, 69% of them were female and 31% male. Overall, 18 schools took part in the research.

The statistical test used was the Wilcoxon signed rank test, which compares the medians of two dependent samples. The samples are considered dependent because participants in both surveys are identical. The first sample consists of participants before the series of energy-related lessons had taken place. The second sample consists of the same participants after the series of energy-related lessons had taken place. Medians were used instead of means because with the ordinal nature of a variable, the mean concept does not make sense. The Wilcoxon signed ranks test examines the null hypothesis that two related medians are the same. Ranks are based on the absolute value of the difference between the two test variables. The sign of the difference is used to classify cases into one of three groups (Table 2): differences below 0 (negative ranks), above 0 (positive ranks), or equal to 0 (ties). Tied cases are ignored. Sum of ranks is the product of N with mean rank. Z is a standardized measure of the distance between the rank sum of the negative group and its expected value.

In order to apply the Wilcoxon signed rank test, responses were enumerated (in a Likert type) as follows: 0 = never, 1 = very few times, 2 = few times, 3 = many times, 4 = very many times, 5 = always. The criterion for statistical significance is a probability (2-tailed significance) less than 0.05, so the probability less than 0.05 indicates that the difference is statistically significant.

Tables 2 and 3 show the questions asked in the survey for pupils and their parents, respectively and Wilcoxon signed rank test results with the significance results. As already mentioned, questions have been formulated in a statement-like way and they indicate what the correct energy behavior is. Furthermore, they show whether the information caused an improvement in the energy behavior towards a more energy-friendly one.

5. Discussion

The first part of the survey depicts the routine energy behavior of pupils and their parents. The second part shows how this behavior has changed after the project implementation, teaching and information provided. Pupils and their parents seem to behave more conscientiously after their involvement in the education process, namely they are more energy efficient.

Three questions in the parents' section (Table 3) did not show the latter though. Non-significance in these questions is justified on the grounds that respondents had already given a high percentage of "always" responses (74%, 73% and 64%, respectively) for those three questions, in the first survey, in the beginning of the academic year. Therefore it is natural to expect that there will be no room for additional energy-thrift behavior development.

Noteworthy is the fact that we do not know whether parents are owners or tenants of their houses. It would be useful to have this piece of information, because tenants, although they may know what energy thrift is and they may be willing to act this way e.g. insulate their house, they nevertheless do not do that, because they are not the owners of their house (Vedung, 1999). Had we taken the above piece information we would have produced richer results and could explain the non-significant results in another perspective. For the vast majority of questions, percentages falling under the answers "never", "very few times", "few times" were reduced, while percentages under the answers "many times", "very many times" and "always" were increased after information.

The fact that information through education makes a significant difference in energy literacy and behavior of pupils

Table 2
Wilcoxon signed rank test results for pupils sample

Question		N	Mean rank	Sum of ranks	Z	P
Do you turn off the lights when you leave your room for more than 2 min?	Negative ranks	72	95.91	6905.5	−4.8018	<0.001
	Positive ranks	138	110.50	15249.5		
	Ties	111				
	Total	321				
Do you turn off the stand- by button of your TV set?	Negative ranks	59	102.31	6036.5	−6.2407	<0.001
	Positive ranks	157	110.82	17399.5		
	Ties	105				
	Total	321				
Do you use rechargeable batteries in your toys?	Negative ranks	81	102.35	8290.5	−5.0869	<0.001
	Positive ranks	150	123.37	18505.5		
	Ties	90				
	Total	321				
Do you know beforehand what you need from the fridge and therefore you open and close the fridge door quickly?	Negative ranks	78	91.62	7146.5	−5.3826	<0.001
	Positive ranks	142	120.87	17163.5		
	Ties	101				
	Total	321				
Do you turn off the air condition in rooms where there are no people?	Negative ranks	42	58.98	2477.0	−3.2890	0.001
	Positive ranks	80	62.83	5026.0		
	Ties	112				
	Total	234				
Do you close the windows when the heating is on?	Negative ranks	36	56.69	2041.0	−1.9949	0.046
	Positive ranks	66	48.67	3212.0		
	Ties	219				
	Total	321				
Do you close the windows when the air condition is on?	Negative ranks	36	46.25	1665.0	−2.1788	0.029
	Positive ranks	58	48.28	2800.0		
	Ties	133				
	Total	227				
Do you close the shutters, shades or curtains to prevent the sunlight from coming in during summer?	Negative ranks	82	105.56	8656.0	−4.3634	<0.001
	Positive ranks	145	118.77	17222.0		
	Ties	94				
	Total	321				
Do you open the shutters, shades or curtains to prevent the sunlight from coming in during summer?	Negative ranks	89	111.31	9907.0	−2.5101	0.012
	Positive ranks	132	110.79	14624.0		
	Ties	100				
	Total	321				
Do you leave your room window wide-open for a few minutes for the air to be renewed?	Negative ranks	63	82.44	5194.0	−4.3751	<0.001
	Positive ranks	118	95.57	11277.0		
	Ties	140				
	Total	321				
Do you prefer showering to bathing in the bath?	Negative ranks	77	101.04	7780.0	−2.2705	0.023
	Positive ranks	118	96.02	11330.0		
	Ties	126				
	Total	321				
Do you check that the water heater is turned off in time?	Negative ranks	73	77.51	5658.5	−1.4797	0.139[a]
	Positive ranks	88	83.89	7382.5		
	Ties	127				
	Total	288				
Do you prefer going on foot somewhere (e.g. school, afternoon private school, park) when it is nearby?	Negative ranks	58	66.22	3840.5	−2.1976	0.028
	Positive ranks	81	72.71	5889.5		
	Ties	182				
	Total	321				

[a] Not statistically significant.

and parents proves that energy education must be promoted and handed as a matter of utmost importance given the environmental risks present today. Schools should have a well-defined policy on energy education with a member of staff responsible for its implementation, coordination and up-dating (Stubbs, 1985).

Table 3
Wilcoxon signed rank test results for parents sample

(After–Before)		*N*	Mean rank	Sum of ranks	*Z*	*p*
Have you seen to curtains or furniture not standing in front of radiators?	Negative ranks	61	60.10	3666.0	−3.3507	<0.001
	Positive ranks	85	83.12	7065.0		
	Ties	144				
	Total	290				
Do you fix your heating or air conditioning temperature at maximum 20 °C in winter?	Negative ranks	59	81.72	4821.5	−3.9539	<0.001
	Positive ranks	112	88.25	9884.5		
	Ties	113				
	Total	284				
Do you fix your air condition temperature above 25 °C in summer?	Negative ranks	50	70.35	3517.5	-4.2557	<0.001
	Positive ranks	102	79.51	8110.5		
	Ties	68				
	Total	220				
Do you use special low electricity consumption lighting bulbs at home?	Negative ranks	76	93.88	7135.0	−4.3437	<0.001
	Positive ranks	132	110.61	14601.0		
	Ties	97				
	Total	305				
Do you receive central heating systems maintenance every year? (This question is answered only if the house has central heating)	Negative ranks	48	45.23	2171.0	−0.0564	0.955[a]
	Positive ranks	45	48.89	2200.0		
	Ties	150				
	Total	243				
Do you check whether your fridge door closes properly?	Negative ranks	47	56.00	2632.0	−1.5809	0.114[a]
	Positive ranks	65	56.86	3696.0		
	Ties	194				
	Total	306				
Do you cook in a pot of the same size as the one in the stove in the cooker?	Negative ranks	65	69.41	4511.5	−1.3254	0.185[a]
	Positive ranks	78	74.16	5784.5		
	Ties	163				
	Total	306				
Do you put only as much water in the pot as you need?	Negative ranks	64	94.49	6047.5	−2.5096	0.012
	Positive ranks	111	84.26	9352.5		
	Ties	131				
	Total	306				
Do you fill up the washing machine with clothes before you operate it?	Negative ranks	64	70.89	4537.0	−3.4321	<0.001
	Positive ranks	97	87.67	8504.0		
	Ties	145				
	Total	306				
Do you check your tyres' pressure regularly? (Respondent answers if he has a car)	Negative ranks	65	91.27	5932.5	−2.8137	0.005
	Positive ranks	111	86.88	9643.5		
	Ties	99				
	Total	275				

[a] Not statistically significant.

The energy awareness and "provoked" energy-efficient behavior must be established through repetition during the school years of project implementation and through the repetition of similar projects during the following school years or/and through more general energy information/awareness projects for youngsters or citizens. This way we "integrate" the energy-efficient behavior into the normal everyday behavior, even though in absence of exogenous inducement to energy saving.

6. Conclusion

Besides the progress required by scientists in devising more energy-thrift technologies, our future depends equally importantly on the energy education provided to all citizens. Education can transform human behavior towards the rational use of energy and increase energy literacy. It provides students, teachers and parents with the opportunity to familiarize themselves with conventional energy handicaps and renewable energy and energy-saving opportunities. Pupils can develop an energy behavior and awareness and transform themselves into sustainable energy-friendly consumers and citizens when they grow up. The information and education venture described in this paper will have multiplier effects, because the "converted" pupils are expected to influence their peers and other people in their environments (family, relatives, friends, neighbors), especially when these pupils will turn into tomorrow's citizens.

During this research, pupils stated what they already knew and realized the limitations of their knowledge as regards the energy content of their everyday activities. Lessons given to them were practical, linked to everyday life and local circumstances and they also had the opportunity to share their experiences with their peers. Furthermore, they proved that they easily assimilated the knowledge provided to them on general energy matters and more specifically on sustainable energy technologies and practices, some of which sometimes they already had heard of, from the media. Energy-efficient behavior can be established by repetition throughout the school year of project implementation by repetition throughout their later school lives. The introduction of a sustainable energy-related module at schools is of utmost importance for society, and as shown in this piece of research, quite effective to students and their peers.

Acknowledgments

This work was financed by the "Force for Energy by Children through education" project, in the framework of the "Intelligent Energy Europe" program of the EU. Thanks are due to Mrs. M. Katantonaki, Mrs. E. Tzagaraki and Mr. D. Dasenakis for their help in informing the pupils and Mrs. I. Paraskaki and Mr. K. Kalitsounakis for their help in data entry. Also thanks are due to the teachers who helped in the implementation of this project.

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