A didactical approach of large-scale electricity generation systems at the elementary school level

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ABSTRACT

This work refers to the organising principles and content of a didactical intervention (addresses to children aged 11-12) related to the concept of energy on large- scale electricity generation systems (thermoelectric power plants, hydroelectric power plants, wind farms, photovoltaic farms). These organising principles refer to: (a) the structure and the content of school knowledge of the teaching subject where we distinguish four levels of approach: the phenomenological, the technological, the scientific and the environmental level, (b) the constructivist approach of teaching and learning science which is based on the assumptions that children in the age of 11-12 years using the linear causal reasoning and the systemic thinking will be able to construct a semi-quantitative energy model that is proper to the description and the explanation of large-scale electricity generation systems, and (c) the pedagogical context based on the practice of problem situations and the socio-cognitive approach of teaching. There will also be presented the didactical aims and some elements of the content of didactical intervention which derive from the basic organising principles above mentioned.

KEYWORDS

Large-scale electricity generation systems, energy chain model, elementary education

RÉSUMÉ

Ce travail se réfère aux principes d'organisation et le contenu d'une intervention didactique (adressée aux enfants âgés de 11-12ans) liée au concept d'énergie concernant les systèmes de production d'électricité à grande échelle (centrales thermoélectriques, centrales hydroélectriques, des parcs éoliens, parc photovoltaïques). Ces principes d'organisation se rapportent (a) à la structure et le contenu du savoir scolaire de l'objet de l'enseignement où on distingue quatre niveaux d'approche : le phénoménologique, le technologique, le scientifique et l' environnemental, (b) à l'approche constructiviste de l'enseignement et de l'apprentissage des sciences naturelles qui est fondé sur l' hypothèse que les enfants de l'âge de 11-12 ans utilisant le raisonnement de causalité linéaire et la pensée systémique seront capables de construire un modèle énergétique semi-quantitative qui est propre à la description et l'explication des systèmes de production d'électricité à grande échelle, et (c) au contexte pédagogique qui est basée sur la pratique des situations-problèmes et l'approche socio-cognitive de l'enseignement. Ils seront également présentés les objectifs didactiques et certains éléments du contenu de l'intervention didactique qui découlent des principes fondamentaux d'organisation mentionnés ci-dessus.

MOTS-CLÉS
Systèmes grand échelle de production d'énergie, modèle de chaîne énergétique, école primaire

INTRODUCTION

This paper focuses on a part of a research concerning the design and the evaluation of the energy approach of large-scale Electricity Generation Systems (EGS) for the upper elementary school level (age 11-12 years). In particular, we present the design principles and the content of a teaching intervention in which the energy approach of EGS is an autonomous object of teaching. This approach differs fundamentally from the approach of the current curriculum in Greece in which EGS is introduced as a small part of a larger unit for energy.

The energy approach of EGS on elementary education displays a number of significant difficulties related to: (a) the nature and the characteristics of the intended knowledge, (b) the cognitive peculiarities of children's thinking and (c) the objectives and the constraints of the curriculum. The intended school knowledge is complex because it engages scientific concepts, technological concepts and representations, as well as environmental matters related to energy management and production (Domenech et al., 2007). It is also known from the related literature that children of that age use mental representations that are not compatible with accepted scientific knowledge (Driver & Millar, 1985) or they have difficulties to understand the social use of energy on large- scale systems (Solomon, 1985). Moreover, it seems that the approach of EGS requires skills of systemic thinking in order to cope with the difficulties deriving from their size and complexity. Finally, the existing curricula of energy study of EGS is not an autonomous subject but fragmentary and superficial. The aim of the wider related research is the design, implementation and evaluation of a teaching intervention to confront the difficulties mentioned above. Here, we present the framework of principles in which this intervention is based.

THE ORGINIZING PRINCIPLES OF THE TEACHING INTERVENTION

Three basic principles were considered for the design of the teaching sequence: (a) the epistemological validity of the subject, (b) the psychological compatibility of school knowledge with the cognitive capabilities of students, and (c) the pedagogical approach of the teaching object.

(a) *The epistemological validity of cognitive subject*. The scientific field which integrates the subject and from which derives the conceptual content of the teaching intervention for EGS is engineering thermodynamics. These technological systems are a special class of thermodynamic systems of energy technology. The term 'energy technology' is referred by Raja, Srivastava & Dwivedi (2006) to the technological applications related to primary energy, particularly to plants and the processes of energy conversion. The energy technology takes into account the overall process of converting energy from the input of primary energy to final delivery of secondary energy.

According to Baehr (1984) macroscopic thermodynamics (first and second laws) is the science background for the engineers providing the conceptual framework for the analysis of energy technology systems. In the context of engineering thermodynamics, which has as object the application of the principles of thermodynamics in technological systems (Hassel, 2009), each study related to a thermodynamic system begins with the definition of the system. The definition of the boundaries of an area in space (the thermodynamic system) related to whatever exists outside of it (environment) is a necessary part of the description of a system (Reynolds, 1974; Baehr, 1984). In a thermodynamic analysis, the object of study is the system and its interaction with the environment (Moran, 1999).

Based to these fundamental points concerning the knowledge of reference for EGS, a conceptual content of the teaching intervention was constructed. The didactical transformation of the knowledge of reference (the school knowledge) refers to four levels of approach:

(i) the *phenomenological*, which contains the definition of the external characteristics of the studied technological systems (thermoelectric power plant, hydroelectric power plant, wind turbines, etc.) and their characteristics. The school knowledge on this level involves mainly the identification and description of the external features of EGS either using photos, or visit to the real EGS.

(ii) the *technological*, which distinguishes the different parts of the technological systems (subsystems) and clarifies the structure and the operation of system components. The size of these systems and their complexity are their inherent characteristics. In order to highlight these characteristics and to deal with the difficulties arising from the limitations of children's thinking three-dimensional representational models EGS have constructed. These representational models are functional, ie, students can construct ideas not only for the technological subsystems of EGS but also on how they work.

(iii) the *scientific*, which describes in qualitative and quantitative terms the thermodynamic systems on which occurs the storage, the transfers and the transformations of energy. On this level, the aim is students to construct the semi - quantitative conceptual model of energy chains. It is suggested that this model is an appropriate form for teaching energy both in preschool (Koliopoulos & Argyropoulou, 2011) and in elementary education (Delengos, 2012), regarding at least the simple small-scale technological systems. The conceptual model of the energy chains is (a) a epistemological valid transformation of scientific knowledge since it is directly linked to the nature and the characteristics of the first and second laws of thermodynamics, (b) it is compatible with a linear causal reasoning, activated to the students from a very early age (see section below) that facilitates the construction of functional knowledge on energy and (c) has been applied successfully in various teaching programs at various levels of education (Lemeignan & Weil-Barais, 1994; Tiberghien, 1996; Koliopoulos & Ravanis, 2001; Delengos, 2012). More specifically, we use the precursors 'function' and 'distribution' models of Lemeignan & Weil-Barais (1994). Our hypothesis is that children aged 11 to 12 y.o. can apply this model to describe small technological systems used in school laboratory as well as EGS.

(iv) the *environmental*, which describes the environmental impact of the functioning of EGSs. The environment is, among other things, the final receiver of the energy quantity which is transferred and transformed into an EGS. Usually, the total amount of energy is being degraded and transferred to the environment in the form of heat resulting the increase of local temperature. This energy is both unusable and disturbs the normal development of ecosystems (e.g the heating of the aquatic environment near EGSs affecting the flora and fauna of the area). Moreover, especially for conventional EGSs, large amounts of pollutants are being discharged causing significant environmental problems (e.g direct impact on the quality of life of the living organisms and contribution to the increase of the greenhouse effect). The proposed school knowledge on this level includes: i) knowledge concerning children's familiarity with the environmental problems mentioned above and which are mainly related to the functioning of conventional EGSs and ii) knowledge highlighting the issue of sustainability of natural resources and related to the environmental impact of EGSs which function with renewable energy.

(b) *The psychological compatibility of school knowledge with the cognitive capabilities of students*. The second principle on which is based the teaching intervention is the constructivist approach to the teaching and learning of science. Despite the fact that children of this age, as noted, use mental representations incompatible with the intended school knowledge, is currently known that, under certain teaching circumstances, even younger children can activate the so-called linear causal reasoning to build a 'qualitative' explanatory model for the energy, in order to describe simple systems, such as the lighting of a lamp or the movement of a small motor using batteries or solar cells (Koliopoulos & Argyropoulou, 2011; Koliopoulos, 2013). Later, in older ages they can also use a semi-quantitative explanatory model to describe also the simple systems (Koliopoulos & Ravanis, 2001; Delengos, 2012). Therefore, we assume that children aged 11-12 y.o. exposed to this teaching intervention will be able to activate the same learning mechanism to construct a model of energy chains for EGSs as well.

Furthermore, we believe that the abstract and quantitative nature of the energy concept can be understood if the systemic thinking is used. The ability to understand and interpret complex systems of all kinds is characterized as systemic thinking. Systemic thinking is, according to Kim (2005), the most modern scientific way of thinking that describes the part - whole relationship. The systemic thinking as cognitive ability can cultivated through the systemic approach of complex technological systems (Hmelo-Silver & Azevedo, 2006; Assaraf & Orion, 2010). In this orientation the teaching suggestions of Huis & Berg (1993) and Jewett (2008a, 2008b) present a particular interest as they relate to teaching the energy in secondary school. The research on systemic thinking presents that students of elementary education can understand concepts of complex systems (Jacobson & Wilensky, 2006), as well as the fact that at the age of 11-12 years they have developed the skills of systems thinking (Wylie et al., 1998). Other studies aim to elucidating the specific characteristics of systemic thinking of children (Christensen et al., 2000; Sheehy et al., 2000; Hmelo-Silver & Pfeffer, 2004). However, is also noted that students face various difficulties trying to obtain this high level skill (Eilam & Poyas, 2010). Regarding the construction of the energy concept has been reported, for example, that students tend to identify the energy to individual objects (Domenech et al., 2007), while the teaching itself, most times, favors this idea when handles the concept of energy on mechanics rather than on thermodynamics (Koliopoulos & Ravanis, 2000). Based on the foregoing, we find that the activation by the students of the linear causal reasoning as well as the development systemic thinking skills are two basic priorities for the design of the proposed teaching intervention.

(c) *The pedagogical approach of the teaching object*. The third principle on which is based the proposed teaching intervention is the socio-cognitive conception for the constructivist approach of science teaching and learning. This approach relies on assumptions according to which preschoolers can construct precursor conceptual models in an environment which favors the interactions between students, teachers and appropriate teaching material (Ravanis et al., 2013). It has been noted that the construction of these models can be realized on instructional interventions in which the teaching objectives have been created based on the cognitive obstacles or in general, on the cognitive capabilities of children of this age (Ravanis & Papamichaël, 1995; Ravanis et al., 2013). Therefore in the proposed teaching intervention is needed to be designed teaching activities which potentially will lead the students to (a) use the cognitive tool of the linear causal reasoning to approach the concept of energy chain (Koliopoulos & Ravanis, 2000; Koliopoulos & Argyropoulou, 2011) and (b) to overcome cognitive obstacles regarding the large scale and the complexity of technological systems constructing skills of systemic thinking.

So, in order to overcome such kind of difficulties, students have been chosen to interact with a number of different representational models of EGSs to activate and/or construct skills of analogical thinking, which requires systemic thinking. These models help students to construct and to handle conceptual models of abstract and non-observable physical entities (Harrison & Treagust, 2000).

The representations used in the instructional intervention are:

(a) Illustrations of the real systems as in figure 1 showing a thermoelectric power plant.

(b) Three-dimensional models of EGSs. In figure 2 we can see a model of a thermoelectric power plant, which is designed in such way that its basic subsystems, such as burner, boiler, turbine, generator and grid, are visible.

(c) A scientific abstract representation, i.e., a version of the energy chain of the functioning of an EGS (figure 3).

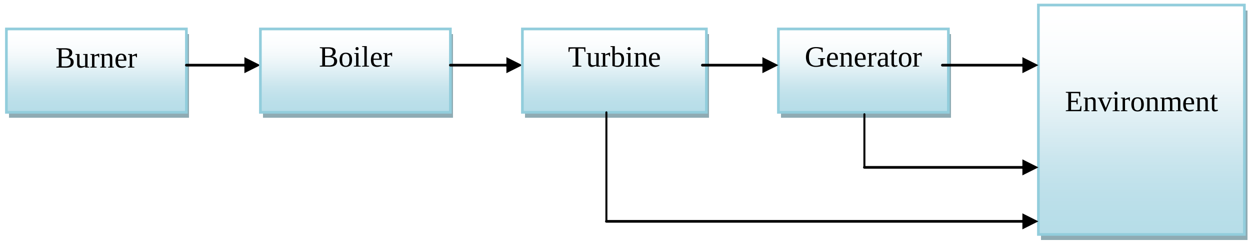
FIGURE 1

Real photo of a thermoelectric power plant

FIGURE 2

3-D model of a thermoelectric power plant

FIGURE 3



Schematic representation of the energy chain corresponding to the energy description of a model of thermoelectric power plant ('function' model)

The use of any kind of representation and their correlation aims to the construction of complementary mental representations of students on the energy approach of EGSs. By the illustrations of an EGS is determined the real technological system and its external characteristics. It consists the reference model for the students, especially when they have no experience of the real system. This kind of representation is suitable for the construction of the phenomenological level of school knowledge. The three-dimensional models highlight the phenomenological characteristics of technological systems represented on a smaller scale in a way that the system is perceived as a whole, while they make visible its structure and functioning. Through them, it is possible to construct the technological and/or environmental level of school knowledge. Finally, the use of the conceptual model of energy chains can lead students to construct the scientific level of school knowledge, ie the energy explanation of the functioning of EGSs.

To obtain the correlation of real technological system with its representations, teaching activities within a visit to a real EGS (especially an hydroelectric power plant)are also introduced Research data show that visits to science and technological museums or to industrial plants not only increase the interest of students to study a related issue but also contribute to their cognitive progress when the visit is associated with systematic instructional activities before and/ or after the visit (Guisasola et al., 2009). In this case students are expected to reach the real system through already constructed phenomenological, technological, scientific and environmental ideas for EGSs in order to apply them to the real technological phenomenon (e.g. to discover themselves the different structural and functional elements of the plant).

On the practical level, problems - activities were designed in order to provoke the appropriate interactions between students, teacher and educational material. The goal is that, during these problems- activities, students understand knowledge in science and technology as result of the study of an open problem. This approach is fully compatible with the hypothetical nature of the concept of energy which cannot be constructed only by experience and observation as often happens in the traditional teaching approach (Lemeignan & Weil-Barais, 1994; Tiberghien & Megalakaki, 1995).

OBJECTIVES AND CONTENT OF THE TEACHING INTERVENTION

The cognitive objectives of the teaching sequence are the following: Students have (a) to recognize and name different types of EGS (phenomenological level of knowledge), (b) to be able to distinguish the different parts of each EGS and describe their functioning (technological level of knowledge), (c) to be able to describe the relationships of connection and interaction among the parts, using a semi-quantitative energy model (scientific level of knowledge), and (d) to be able to identify the environmental impacts from the functioning of a EGS (environmental knowledge level).

Teaching activities

The various activities-problems were organized in four thematic units: (a) *What is an EGS - The thermal power plant*, (b) *Renewable energy sources and EGS*, (c) *Measurement of energy in EGS*, (d) *EGS and daily life*. There were designed 11 subunits (table).

TABLE

The structure of the content of the teaching sequence

Unit	Subunit	School knowledge	Main activity-problem
A	1	Phenomenological level	What's behind the plug?
	2	Technological level	How does a thermoelectric power plant works?
	3	Scientific level	Why the lamps light up?
B	4	Environmental level Technological level Scientific level	How can we reduce or avoid air pollution generated by the thermoelectric power plant?
	5	Technological level	How does a hydroelectric plant works?
	6	Scientific level	How is made and how it works a wind turbine?
C	7	Technological level Scientific level	What will happen to a plant if you need to use more electrical devices? What will happen to a hydroelectric plant if you need to use lamps of greater power?
	8	Technological level Scientific level	How we measure the amount of energy transferred from the power hydroelectric plant?
	9	Technological level Scientific level	How we pay the power supply company; How much energy is transferred to the lamps of the classroom? Can we measure it and how?
D	10	Environmental level Technological level Scientific level	Why change the incandescent lamps?
	11	Phenomenological level	How is a real hydroelectric plant?

Example of a teaching activity

A typical example of the proposed teaching activities is the subunit 4 ("*How can we reduce or avoid air pollution generated by the thermoelectric power plant?*"). The corresponding worksheet is shown in *appendix 1*. In this subunit, an attempt is made to activate three levels of school knowledge (technological, scientific, environmental) in response to an environmental problem, that of air pollution. More specifically, in the first activity students discuss and highlight the basic characteristics of the environmental problem (emission of carbon dioxide), while they are been asked to measure the carbon dioxide levels before, during and after the functioning of a 3-D model of a thermoelectric plant in three different distances. Based on these measurements, they draw their first conclusions and then they study the inserted text 'scientific information'. The second activity raises the critical question “How are made pollutants”. Thus, students should seek the answer to the technical description of the system correlating the pollutants to the burning conventional fuel. In the third activity, an attempt is made to focus the discussion on the type of technological system that can replace the burner or other technological elements of the system in order to resolve the environmental problem. The fourth and fifth activities aim to discuss the pollution problem from the energy point of view in order that students understand its quantitative nature and its relation to energy needs. In these activities, therefore, students have to move to the scientific level of the school knowledge. Thus, all of these activities-problems, are leading potentially to the construction of a multidimensional knowledge without which it is not possible to answer these specific problems.

EPILOGUE

The teaching intervention, the basic principles and the content of which is presented in this work has been already implemented in classrooms in order to confirm or refute hypotheses according to which students aged 11-12 are able to construct a semi - quantitative energy model to explain the functioning of certain EGSs, the environmental impact of their functioning and the relation of EGSs with their daily live. This research continues with the study of various data obtained before, during and after the application of this sequence. An initial analysis of these data (Sissamperi & Koliopoulos, 2014) shows that almost all students at the end of the intervention are able to describe and explain the functioning of not only the technological systems that were included in the teaching intervention, but also of an unknown technological system (photovoltaic farm), using at least qualitative elements of the model of the energy chain.

REFERENCES

Assaraf, O., & Orion, N. (2010). System thinking skills at the Elementary School level. *Journal of Research in Science Teaching, 47*(5), 540–563.

Baehr, H. D. (1984). *Thermodynamics: Introduction in fundamental and in the technical applications* Thessaloniki: Giahoudis-Giapoulis (in Greek).

Christensen, D., Spector, J., Sioutine, A., & Mc Cormack, D. (2000). Evaluating the impact of system dynamics based learning environments: Preliminary study. Retrieved from http://www.systemdynamics.org/conferences/2000/PDFs/christen.pdf.

Delengos, N. (2012). The construction of the concept of energy and its social use by 9-10 y.o. students of the Greek primary school. PhD Thesis, Patras, University of Patras, Patras (in Greek).

Domenech, L. J., Gil-Perez, D., Gras-Marti, A., Guisasola, J., Martinez-Torregrosa, J., Salivas, J., et al. (2007). Teaching of energy issues: A debate proposal for a global reorientation. *Science & Education, 16*, 43-64.

Driver, R., & Millar, R. (Eds). (1985). *Energy matters.* Leeds: University of Leeds, Centre for Science and Mathematics Education.

Eilam, B., & Poyas, Y. (2010). External Visual Representations in Science learning: The case of relations among system components. *International Journal of Science Education, 32*(17), 2335-2366.

Guisasola, J., Solbes, J., Barragues, J.-I., Morentin, M., & Moreno, A. (2009). Students' understanding of the Special Theory of Relativity and design for a guided visit to a Science Museum. *International Journal of Science Education, 31*(15), 2085-2104.

Harrison, A., & Treagust, D, (2000). A typology of school science models. *International Journal of Science Education*, *22*(9), 1011-1026.

Hassel, E. (2009). *Technical Thermodynamics*. *Chapter 1: Introduction, some nomenclature*. Rostock: University of Rostock, Germany Faculty of Mechanical Engineering and Ship Building Institut of Technical Thermodynamics. Retrieved from http://www.ltt.uni-rostock.de/uploads/media/TTD_book_chap_01_109.pdf.

Hmelo-Silver, C., & Pfeffer, M. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science*, *28*, 127–138.

Hmelo-Silver, C., & Azevedo, R. (2006). Understanding complex systems: Some core challenges. *The Journal of the Learning Sciences, 15*(1), 53–61.

Huis, V. C., & Berg, E. (1993). Teaching energy: A systems approach. *Physics Education, 28*, 146-153.

Jacobson, M., & Wilensky, U. (2006). Complex systems in education: Scientific and educational importance and implications for the learning Sciences. *The Journal of the Learning Sciences*, *15*(1), 11–34.

Jewett, W. J. (2008a). Energy and the confused student II: Systems. *The Physics Teacher, 46*, 81-86.

Jewett, W. J. (2008b). Energy and the confused student III: Language. *The Physics Teacher, 46*, 149-153.

Kim, M.-H. (2005). *An implication of system thinking paradigm in current science education, Key Engineering Materials*. Switzerland: Trans Tech Publications, vols. 277-279, p. 299-304.

Koliopoulos, D. (2013). Is it possible to teach energy in preschool education? In F. Tasar (Ed.), *Proceedings of the WCPE Conference*, (pp. 451-455). Istanbul: Pegem Akademi.

Koliopoulos, D., & Argyropoulou,. M. (2011). Constructing qualitative energy concepts in a formal educational context with 6-7 year old students. *Review of Science, Mathematics & ICT Education, 5*(1), 63-80.

Koliopoulos, D., & Ravanis, K. (2000). Elaboration et évaluation du contenu conceptuel d'un curriculum constructiviste concernant l'approche énergétique des phénomènes mécaniques. *Didaskalia*, *16*, 33-56.

Koliopoulos, D., & Ravanis, K. (2001). Didactic implications resulting from students' ideas about energy: an approach to mechanical, thermal and electrical phenomena. *Themes in Education, 2*(2-3), 161-173.

Lemeignan, G., & Weil-Barais, A. (1994). A developmental approach to cognitive change in mechanics. *International Journal of Science Education*, *16*(1), 99-120.

Moran, M. J. (1999*)*. Engineering Thermodynamics. In F. Kreith (Ed.), *Mechanical Engineering Handbook*. Boca Raton: CRC Press LLC. Retrieved from http://f3.tiera.ru/ShiZ/Physics/Mechanical%20Engineering/ME%20Handbook/Ch02.pdf.

Raja, A., Srivastava, A. P., & Dwivedi, M. (2006). *Power plant engineering.* New Delhi: New Age International.

Ravanis, K., & Papamichaël, Y. (1995). Procédures didactiques de déstabilisation du système de représentation spontanée des élèves pour la propagation de la lumière. *Didaskalia*, *7*, 43-61.

Ravanis, K., Papandreou, M., Kampeza, M., & Vellopoulou, A. (2013). Teaching activities for the construction of a precursor model in 5-6 years old children's thinking: the case of thermal expansion and contraction of metals. *European Early Childhood Education Research Journal*, *21*(4), 514-526.

Reynolds, C. (1974). *Energy from nature to man*. New York: McGraw-Hill.

Sheehy, N., Wylie, J., McGuinness, C., & Orchard, G. (2000). How children solve environmental problems: using computer simulations to investigate system thinking. *Environmental Education Research*, *6*(2), 109-126.

Sissamperi, N., & Koliopoulos, D. (2014). 6th grade students' conceptions about electricity generation systems. Paper presented at "*The Sustainable energy education from the very early years*" conference. Department of Educational Sciences and Early Childhood Education, University of Patras, Greece, 13 June 1014.

Solomon, J. (1985). Teaching the conservation of energy. *Physics Education*, *20*, 165-170.

Tiberghien, A. (1996). Construction of prototypical situations in teaching the concept of energy. In G. Welford, J. Osborne & P. Scott (eds), *Research in Science Education in Europe. Current Issues and Themes* (pp. 100-114). London: Falmer Press.

Tiberghien, A. & Megalakaki, O. (1995). Characterization of a modelling activity for a first qualitative approach to the concept of energy. *European Journal of Psychology of Education*, *10*(4), 369-383.

Wylie, J., Sheehy, N., McGuinness, C., & Orchard, G. (1998). Children's thinking about air pollution: a systems theory analysis. *Environmental Education Research*, *4*(2), 117-137.

APPENDIX

Unit 4: Worksheet

The air pollution problem

1. With the help of teacher use the CO_2 sensor for measurement and record the measurements in the following table. The measurements will be applied in three different times, before triggering the thermal power plant, during its operation and after its shut down.

Location	CO_2level Before	CO_2level During	CO_2level After
Near the thermal power plant			
1 meter distance			
5 meters distance			

Which is the conclusion?

Scientific information

The CO_2 (carbon dioxide) is a gas that comes from burning fossil (such as oil, lignite, natural gas, etc.) but also by burning wood and plastic or other materials. Moreover, it comes from the decomposition of dead parts of living organisms(plants and animals).

Αέριο	Περιεκτικότητα
Άζωτο	78,08%
Οξυγόνο	20,95%
Αργό	0,93%
Διοξείδιο του άνθρακα	0,035%
Νέο	0,0018%
Ήλιο	0,00052%
Μεθάνιο	0,00014%
Κρυπτό	0,0001%
Οξείδια του αζώτου	0,00005%
Υδρογόνο	0,00005%
Όζον	0,000007%
Ξένο	0,000009%

Εθνικό Αστεροσκοπείο Αθηνών

Under normal conditions, the CO_2 is an ingredient of the air with small concentration. Thus, its increase creates many problems to people and to the environment.

The main problem is the **intensity of the greenhouse effect**. This natural phenomenon is a mechanism to maintain constant the temperature of the earth. However, the increase of CO_2 level is responsible for the significant increase in temperature, as it creates a layer which prevents the sun rays return to space.

In order to be informed better about the greenhouse effect, you can watch with your team the video in the following website:
http://www.youtube.com/watch?v=tPMad2A7zAA

2. The thermoelectric power plants are responsible for the creation of pollutants contaminating the environment. How the pollutants are created? Discuss this issue with your team and write down your ideas.

3. How can we reduce or avoid air pollution created by a thermoelectric power plant? Discuss this issue with your team and write down your ideas.

4. The pollutants will be increased or reduced if:

we have to light up fewer lamps	
we have to light up more lamps	
the lamps light up for a longer period	
the lamps light up for a shorter period	

5. What changes would you do in energy chain of a thermoelectric power plant to show how the pollutants can be reduced or eliminated?