
Environmental education through science and technology projects: two case studies

Educación ambiental a través de proyectos de ciencia y tecnología: estudio de dos casos

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Abstract

Success in a profession depends on how the learner is capable of applying theory to practice. This study presents a project method, which is recommended to achieve the principles of scientific application. The project presents a problem in which the learner feels that he is facing an unfamiliar situation that requires the search for solutions under the guidance of the teacher. The importance of the project increases if it has clear objectives, a research and problem solving method, educational and social values and if the learner himself organizes and carries out the project with the teacher's help. The study presents two case studies: the first is on water pollution and the second is on solar energy. For each case study, the learner must state the general and learning objectives, draw and execute the plan, evaluate the method, state the problem and hypotheses, carry out the investigation and draw the conclusions. In general, teachers who guide students in such methods must be prepared and well informed about both, the project method and subject matter of the project cases that the students select.

Keywords: Science Education, Environmental Education, Projects, Water Pollution, Solar Energy

Resumen

El éxito en una profesión depende de cómo sea capaz el aprendiz de aplicar la teoría en la práctica. Este estudio presenta el método de proyectos diseñados para enseñar los principios de aplicación científica. El proyecto es un problema donde el aprendiz siente que está enfrentado con una situación poco familiar que hace necesario la búsqueda de soluciones bajo la guía del maestro. La importancia del proyecto aumenta si tiene los objetivos claros, los métodos para resolver problemas, el valor educativo y social y si el estudiante puede organizar y llevar a cabo el proyecto con la ayuda del maestro. El proyecto presenta dos estudios del caso: el primero - sobre la

polución de agua y el segundo - sobre la energía solar. Para cada caso, el estudiante debe comprender los objetivos generales y de estudio, diseñar y ejecutar el plan, el método de la evaluación, comprender el problema, la hipótesis, método de investigación y hacer las conclusiones.

En general, los maestros deben ser preparados sobre esta metodología y también sobre el contenido de los proyectos seleccionados.

Palabras clave: Educación de la ciencia, Educación ambiental, Proyectos, Polución de Agua, Energía Solar.

INTRODUCTION

Many individuals do not succeed in their work possibly because they did not have the opportunity to apply what they learned at school. They went out to the real life without the practical experience. The use of projects is recommended to achieve the principle of scientific application and to increase interest and motivation for the learner. For example, a nursing student would not be able to give injections depending only on the lecture s/he hears; the instructor must demonstrate and finally the student must develop competence in the skill personally. Educated individuals can never be integrated into their society and be professionally well prepared unless they become trained to apply what they have learned to the benefit of their society. Therefore, the project-method is based on the principle of scientific application. The project provides a problem where the learner is required to face an unfamiliar situation (Cothorn et al, 2000; Cothorn et al, 2000a; Schwab, 1960; Collins & Maghieri, 2000). In such situation, whether a question or anything else, the learner is motivated to find an answer. The teacher selects the suitable problem for the learner's level, and presents it in an attractive and interesting manner. It is preferable to bring

an educational problem based on the learner's experience and interests. The importance of the project increases if it includes the following elements (Cothorn et al, 2000; Cothorn et al, 2000a; Schwab, 1960; Collins & Maghieri, 2000):

- Has clear objective for the learners.
- Includes research and problem solving method.
- Is educational and social value for the learner.
- Requires the learner to organize and carry out the project (with the teacher's help.)

In the project, the teacher guides the learner/s (individuals or groups) to take responsibility for the planning and execution of the work. The learner must be encouraged to have the confidence to use her/his skills and abilities to study the environment and detect phenomena and problems within the objectives of science teaching and the project's method. This helps to achieve the goals of integration in teaching science and the promotion of the learner's development to the extent of her/his potential. The educational project is devised according to the following principles:

- The learner's personal motivation and interests.
- The relevance of the project to the learner's environment and future needs.
- The work of scientific integration toward the promotion of a variety of educational objectives, the integration of teaching all relevant branches of science in the project, and to make the project contribute to the promotion of the learner's skills in different subjects (Sciences, mathematics, geography, languages, ...).
- The aim of the project is to discover and develop the learners' preparedness and capabilities through their use of different skills and their gaining of appropriate knowledge and understanding.
- The project may be for an individual or a group. The individual project is the one where one learner is committed to carry it out. While in the group project, several learners act as a team to execute it in order to achieve its clear objectives.

Steps of the project method (Cothorn et al, 2000; Cothorn et al, 2000a):

The teacher needs to plan the steps of the educational project during the planning phase. Where possible these need to be negotiated with the learners. Some of these steps are:

- a. Selection of the project, specification and description of the project goals for the learner. There might be a variety of educational projects. Therefore, the teacher must select the project that suits the learners' levels and answer to their needs.
 - Fitting the project to the learners' needs and levels. For example, will they learn the science they need and does it fit their capabilities?
 - Will the project achieve educational, practical and economical benefit to the learner?
 - The project must achieve educational goals. Following the selection of the project by the learners themselves, the teacher must provide guidance and encourage learning attitudes that create the learners' interest to carry out the project. The teacher will negotiate the project's goals with the learners. S/He must start with the developing goal of the learners in order to achieve educational goal that s/he set for them.
- b. Setting the plan: The teacher discusses with the learners the practicable steps on which the project is based. The methods and the required capabilities must be specified, as well as the processes to be followed during the execution.
- c. Project execution: The teacher gives most of the responsibility to the learners for carrying out the work plan (but remains available to provide support/advice if necessary).
- d. Evaluation: The teacher discusses with the learners the knowledge and skills they have acquired, the task they carried out, the instruction and empowerment they received during the daily activity. Students and teacher suggest improvements in the project and the teacher provides a summative report. If possible a summary of the project with information and pictures is made available to *all* the students and to the community. The following are some of the educational project's features:
 - The learner acquires scientific thinking through learning, research and questioning activities.
 - Exposure of the learner to complete educational experience.

- Linking the learner to the environment.
- Promoting the learner's continuity of self-learning.
- The teacher is able to follow up the learner's behavior during the learning activities.
- Reporting outcomes to others (sharing learning) across the peer-group and the whole community.

From the disadvantages of the educational project is the fact that it needs high teaching skills (specialized teachers), several schools and local abilities and long time.

First Case: Water pollution (Cunningham, 1994; Manahan, 1994; Tyler, 1989; Hugerat & Basheer, 2001; Hugerat & Basheer, 2001a).

General objectives:

- To promote the learners' capabilities to research.
- To become familiar with measures of pollution levels in water
- To promote the learner's awareness to the importance of water resource preservation in the environment, home and school.

Special objectives (Learning objectives):

- The learner becomes familiar with the clean water (drinking water) and the unclean water.
- The learner becomes aware of the significance of water in her/his life and the importance of not wasting it.
- The learner distinguishes between clean and polluted water.
- The learner suggests the causes of pollution.
- The learner confirms the causes of pollution.
- The learner explains the diseases that caused by pollution.
- The learner concludes the methods of prevention and treatment of diseases.
- The learner gets training on the use of some scientific equipment that is used to detect pollution.
- The learner perfects the methods of adding appropriate chemical material to sterilize the drinking water at school and at home.
- The learner gets the opportunity to carry out some experiments to analyze pollutants in the water.
- The learner sketches some scientific drawings for what he has learned.
- The learner becomes trained on how to maintain and clean the drinking water storage facilities at school.
- The learner values the importance of conserving water resources.
- The learner compares the water used in the experiment to the conditions of healthy water.
- The learner's desire in continuing self-education from different sources is promoted.

Testing of the project and clarifying the goals:

Discussion with the learners may encourage the teacher to select this subject as an educational project, or to utilize different methods to make the learners more interested in using the learning techniques. For example:

- The teacher brings different samples of water (A, B, C), given that the samples are taken from different environmental sources (some of which are polluted).
- The teacher instructs the learners to take one drop from each sample and to examine it under the microscope.
- The teacher discusses with the learners their observations and findings in each sample. They should conclude that some samples contain microorganisms. Here, the study objective must be made clear to the learners, and to guide them to the subject of "Water Pollution".

Drawing the plan:

The teacher must clarify for the learners the basic elements of the project to be undertaken. Afterwards, they specify the water source they want to study (school, home, ...). Following that, they visit the water source for the neighborhood in order to take the sample, analyze it and record the results. They, then, select another water source such as old water storage, take a sample, test it and record the results. The learners must be aware of how to make comparisons, methods of the study, and the equipments used

in the experiment. The learners may be advised to interview water experts and to visit the library to review some articles.

The teacher must discuss this with the learners and to set the study priorities according to a specific time schedule.

Execution of the plan:

In this stage, the learners execute the work that they have planned. For example:

- They make a visit to the specific water sources, take the samples to the laboratory, analyze the data, write down the results and set the instructions.
- Visit the specialty sides in order to know the different methods of preservation of water and the sources that are added. Thus, the specific elements for the lesson are completed. The teacher then must guide toward the learning methods.

Evaluation:

Through the learners' participation in learning, their testing of the samples, writing the results, interviewing environmental specialists, they can understand the extent of benefit (experience and skills) they gained. The teacher may also follow-up the development of the learner's behavior during the work, in addition to the reports, drawings and articles.

We may propose educational projects on environmental pollution including water, air and sea pollutions with which the teacher tries to interest the learners in a variety of ways. As a result, they reach to:

Problem statement:

Environmental pollution is a problem that leads to tremendous health troubles at both individual and community levels (Cunningham, 1994; Manahan, 1994; Tyler, 1989). Afterwards, the teacher asks the learners for their opinions about the causes of the environment pollution. First, they describe their observations in their daily life at home, at school, in the street, and then the opinions are formulated in the form of hypotheses.

- Hypotheses
- 1. Gases emitted from factories lead to pollution.
 - 2. Trash causes pollution.
 - 3.

Investigation:

The teacher instructs the learners to gather evidence as much as they can within their capabilities and their visits to the places near their residence. In addition, they may gather different studies relevant to the subject as well as seeking the opinions of the parents in this topic.

Reaching conclusion:

Gathering evidence relevant to every hypothesis is completed. The teacher, then, discusses each hypothesis on the bases of the available data in order to reach a scientific conclusion that enables them to formulate suggestions for minimizing pollution and its problems.

The Second Case: Solar energy-Science and Technology in Clean Society

Introduction

Baka-Algarbia is a small; the name Baka means a bunch of flowers. Its population is about 18000 people. The town is famous for its green houses (plastic houses), and about 60 percent of the people grow vegetables according to this method of agriculture. They export the products to Tel-Aviv and Haifa markets. The town is also famous for its factory with solar-heated boilers. The products of the factory are exported to the Arab neighbouring states.

Iben Khaldun school got the national prize of the most beautiful school in the year 1992. There are 654 pupils who learn from the kindergarten to the 6th grade. More than 60 percent of their families make living from greenhouse agriculture. These two main factors – green houses and the factory, both of which depend on direct use of solar energy motivated us to choose the solar energy project.

The word energy means the ability to do work. The need for energy in the world increases to a great extent because of the human population growth and the use of technology. On one hand, energy is very important in daily life, and the demand for energy continues to grow worldwide. On the other hand, however, sources of the combustible fuels we depend on, such as coal, oil, and gas are finite (Richard & Eri, 1993; Tomas, 1996; Clark & Eckert, 1975; Hugerat & Ilaiyan, 2001; Hugerat et al, 2001; Kedem & Ganiel, 1983; Hodges, 1996). In addition, the increased burning of fossil fuels raises concerns over global warming and air pollution where controls are lax (Richard & Eri, 1993).

Since we are so dependent on fossil fuels for energy, and they are running out, it is necessary to find alternative energy sources. One of the alternative energy sources is the sun. Solar energy is energy direct from the sun. Without solar energy, life would be impossible. Plants need the sun's energy to grow, winds would not blow without the sun, and the earth would be a cold, dark, planet. We use sunlight and heat from the sun to dry clothes outside. The sun's heat can be used to warm water flowing through pipes on a roof, sunlight can also be concentrated in a solar thermal system to heat water to make steam. The steam can be used to turn turbines to make electricity (Richard & Eri, 1993).

Electricity can also be produced directly from the sun's energy by making a photovoltaic cell. Photovoltaic solar systems are one of the most exciting technologies ever invented. They are used to generate electricity, they are quiet and environmentally safe and the electricity can be used to produce other fuels – such as hydrogen – that can be stored. Photovoltaic cell is made up of very thin layers of silicon (Clark & Eckert, 1975; Hugerat & Ilaiyan, 2001; Hugerat et al, 2001; Kedem & Ganiel, 1983; Hodges, 1996).

The schools are an ideal place to use solar energy. Changes and improvements at schools are highly visible and closely followed. Bringing solar energy as an educational initiative to schools increasing the use of solar energy in the community at large. When the educational initiative starts to work, the school will host the solar energy systems that will become a commonplace tomorrow in public buildings, homes, and businesses. Schools make a good showcase for the benefits of solar photovoltaic electricity and pupils will educate their parents that solar energy is clean, almost limitless and can be used for lighting, heating, and cooling.

The main educational and pedagogical aims for the project

The issues in the curriculum of science and technology which our project is based on are energy, technological products, information, communication and ecology. The aims of our project according to the scientific, technological and social aspects are:

- 1) To develop an independent learner, who chooses, plans, produces, gains experiences, searches and is capable of working in a team.
- 2) To foster pupil learning in a research environment.
- 3) To write a special school curriculum about the issue of solar energy ranch.
- 4) To develop awareness of environmental and ecological issues.

Description of the activity

- a. Learning about new methods of working in school.
- b. Learning about the environment and communication.
- c. Recognizing a number of different sources of information.
- d. Through the preparation for the project solar energy ranch, the pupils will be exposed to technology and its contribution to our life today and its influence on our life in the future.
- e. Finding out solutions for ecological problems caused by technology.
- f. Our pupils learn in work groups using research and exploratory methods.

We believe that through the implementation of the project the pupils learn how to be creative. Our pupils use scientific journals during their search for theoretical material, as well as the internet.

The process and the stage of the implementation

The process of developing the project includes planning, learning, feedback, and evaluation. Through research and group-work of the pupils, they get a first hand experience in scientific, technological and social aspects and the ways of finding out about solar energy. The pupils are trained by their teachers to build a big model of solar energy ranch and learn how to establish a research lab concerned with the direct use of the sun's energy.

Operational goals and working program:

1. To teach the teacher about sun energy, its uses and the need of this energy in enhancing advanced technology. In this step, it is very important that the teacher has an experience of different technology methods and prepares study-material for the pupils about the solar energy subject for the solar village. The teacher may visit a place that uses solar energy in daily life or a place that investigates the solar energy.
2. To expose the pupils to the subject of the educational initiative. Here, we will introduce advanced technology instruments on the subject of solar energy to the pupils.

3. In activities with investigation group, the pupils deal with the scientific, technological and social aspects of solar energy. It will involve the pupils in an investigational activities on the subject of solar energy. With the teacher's instructions, the pupils will work as a team.
4. The pupils will construct a big model of solar village inside the school. Everything that operates on energy will use the solar energy such as lighting, TV, computers, communications, transport. The pupils will also build a small solar car which moves in the school courtyard.

Short description of the product

The school pupils succeeded, under the direction of their teachers, in building a big model of a typical solar energy 'ranch' on which all the things operated by solar energy. These things include a small car. The pupils and their teachers prepared a special school program about the issue of "Solar Energy". The pupils wrote many short reports about the importance of energy for the continuity of mankind. The teachers became much more confident today than before, because they succeeded in completing such a long study about the issue.

The community strengthened its ties with the school, many parents visit the school every day, in order to learn how to save energy and find out how to use the instruments in the ranch. Many school teams visit our school every week from many different towns and villages. The ranch became a very attractive visiting place.

In this educational initiative, we indicate that the pupils became active participants in building systems that use solar energy to work and understand the relation between the knowledge of the basic science in solar energy and the technology process in daily life. The pupils enjoyed the ranch and its instruments like the windmill and four poles of electricity lighted by solar energy. A water fountain was built at the entrance of the school. It gives a very beautiful inspiration for every visitor. The school became a good meeting place for every one.

The implementation of these educational projects showed that it stimulates the students' interest socially and educationally.

Most students admitted that the project's impact was positive, and somehow it changed their way of thinking and enhanced their creativity. For example, they pointed to the strong relation between the acquired topics during the project and their understanding of the sun's importance, on one side, and the practice in their daily life, on the other. This reflects the project's great benefit to the students by making them capable of relating the material they learn to the events of their daily life. A great majority of the students showed support to the conversion of the solar village project to reality in their homes.

The vast majority of teachers admitted that the initiative has promoted the students' capabilities and creativity and highlighted the educational and social aspects of the children's readiness to participate with each other and teachers in learning projects and to discuss and exchange ideas with others. The project gave the children the opportunity to use their skills that are, in most cases, undetected or neglected.

The study results show that almost all the teachers are willing to participate in educational projects inside the school. This indicates the positive impact of these projects on the schools that carry out such projects.

The majority of parents were supportive of the projects because it gave their children the opportunity to participate. Most parents followed the progress of the projects by visiting the school, offering help and observing their children's involvement with great interest in the projects.

Parents also saw a positive impact of the projects and expressed willingness to be among the first ones to apply them in actual life.

CONCLUSIONS

Teachers, pupils and parents asserted the positive impact of the project educationally and socially.

The execution of educational projects inside the school promotes creativity and thinking ability among students.

Teachers considered such projects quite important due to the students' interaction and interest.

Such projects increase the mutual relations and interactions between students and their teachers, which leads to the success of the school. In addition, it strengthens the school-community relations led by parents' numerous visits to the school during the execution of the projects. Afterwards, parents continue to visit the school.

The execution of such educational projects provides the students with basic concepts and terms from their own surrounding and improves their understanding of their environment.

It also improves the learning skills of the students such as reading plans, executing research and writing reports.

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Received 23.05.2003, approved 05.03.2004