

Sustainable education in the CECYT11, National Polytechnic Institute, Mexico.

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ABSTRACT:

The National Polytechnic Institute in Mexico is a leading institution in technological education and in its institutional development plan sustainable education in its community is a transversal axis. A sustainable garden can have a great environmental, social and economic impact. The objectives were: 1) To design a sustainable garden 2) To induce students to research. The active didactic strategy of project-based learning was applied to a group of 60 students of the sustainability career who were divided into teams to propose a model of sustainable garden that could be built in the school. This activity induces students to be creative and interested in research, to think critically and to manage information. The students proposed a functional model. In the new generations, sustainable education must be developed and strengthened, to carry out actions that promote the care of the environment. Technology in support of environmental care in CECYT 11, a sustainable school 20251232, 20251136 and SIP 20254457. National Polytechnic Institute, Mexico.

KEYWORDS: Sustainability, chemistry, research education, project-based learning

1) Introduction:

When talking about sustainability and sustainability there is great controversy because they are sometimes used as synonyms, but there are important differences that must be considered in environmental education, the two words derive from the English "sustainability", a term used in the Brundtland report and from the Latin "sustinere", which means to sustain or maintain. The use of one word or another depends on the context and the country that uses it.

Sustainability must be studied from a practical and ecological approach, in which the ability of natural systems to maintain and recover balance when it is broken naturally or caused by human activity must be considered. The United Nations (UN) as an international organization has held several meetings for the care of the environment, thus in the Brundtland Commission of the General Assembly of 1983 and its report "Our Common Future" presented in 1987 the term sustainable development and the integration of environmental, economic and social policies appeared as pillars of sustainability. Sustainable development is understood as: "Meeting the needs of the present without compromising the needs of future generations" [1], [2]. Later, in 1992, the UN in Rio de Janeiro held a conference on environment and development (UNCED), which produced the Rio Declaration that contains principles and is the formal instrument of the concept of sustainable development. Subsequently, in 2002, the World Summit on Sustainable Development was held in Johannesburg, which highlighted the importance of poverty in sustainable development, as well as sustainable consumption and production [2].

In environmental sustainability, there must be the harmonious coexistence of society and its environment, where the present population can satisfy its needs and improve its well-being by using the available natural resources in a rational way, taking care of the planet and the different species that inhabit the planet.

On the other hand, sustainability must have to do with a comprehensive, systemic and multidimensional approach: environmental protection, social equity, economic and cultural development, in balance for the well-being of man and ensuring the health of the planet. Sustainability is closely related to the Sustainable Development Goals (SDGs) indicated by the UN in the 2030 agenda, including SDG 2 zero hunger and 11 sustainable cities and communities [3], [4].

In the world, actions are being taken to reduce hunger caused by the overpopulation of the planet, the land with poor nutrients for cultivation, pests, climate change, diseases, armed conflicts, among other factors, make it necessary to take actions to reduce hunger and food insecurity that lead to malnutrition and health problems in the countries. On the other hand, the community must be safe and sustainable, for this it is necessary to carry out actions such as the design and implementation of school and urban gardens [3].

Since ancient times, pre-Hispanic peoples such as the Aztecs and the Incas took care of the land and crops, using the technique of terraces and chinampas to enrich the land and optimize the use of water, for the benefit of man and the various species of flora and fauna, through a natural method of water absorption in the case of the chinampas in Mexico [5].

Currently there are urban, family or backyard and school gardens. A school garden is a space in which edible plants, vegetables, aromatic, ornamental or medicinal plants can be grown, in the playgrounds, open and sunny spaces, in whose care students, teachers and directors participate; to provide the water and nutrients that the plants need [6].

There are currently indicators of damage done to the earth, including climate change, desertification, extinction of species, pollution of the land, the atmosphere and bodies of water [7]. Industries, government, society, non-governmental organizations and schools that provide knowledge of hard disciplines, as well as green culture, innovation and sustainable activities in the community such as reducing, rejecting, recycling, reusing and reusing different products must participate in caring for the environment [8]. In public or government universities such as the IPN in Mexico, which carries out actions to be a sustainable institution, it inserts content with a sustainable approach for young people to help in the care of the environment, as a transversal objective throughout the academic education of young people, so simultaneously in their subjects they are educated to care for the environment. The students are induced to carry out cutting-edge research in which they must identify priority environmental problems, so new educational practices must be carried out and teachers must be updated. On the other hand, it must be considered that education must be comprehensive, for these spaces are opened within the school that promote art and culture in a school in the area of engineering, physics and mathematics such as the CECYT11 Wilfrido Massieu.

To develop or strengthen research, as well as environmental education and awareness at the National Polytechnic Institute (IPN), the project-based learning (PBL) didactic strategy is carried out.

The systematized procedures and actions that facilitate the teaching-learning process are the didactic strategies in which various resources and means are used to achieve the significant learning of the student [9], [10].

Teaching strategies used in the classroom and other learning environments include project-based learning (PBL), science, technology, engineering, art, and mathematics (STEAM) approach, debate, case studies, flipped classroom, problem-based learning, gamification, collaborative work, challenge-based learning, chiefly, PBL is a didactic strategy that induces students to research and prepares them to learn to work in collaborative, innovative, creative, active and interdisciplinary work teams [11].

In 1960, PBL emerged at the University of Canada as a didactic strategy, as a method of active learning of students, this method was different from traditional education in which the teacher was the one who transmitted knowledge to the student who had a passive attitude in his learning and only memorized the information provided [12]. The student has an active role in their significant learning in PBL, because they identify a problem in the environment, carry out observation, analysis and integrate previous knowledge of their personal experience in the classroom, laboratories, workshops and their daily life, of the subjects they study throughout their academic and technical career at the school, making use of strategies and the scientific method of research, in a work in interdisciplinary teams that in the end [9], [13]. This learning strategy is based on constructivism and the work of Piaget, Vygotsky and Bruner who indicate that learning is continuous, dynamic, social and continuous, in addition to the mental models that lead the individual to knowledge [14].

In PBL, the student is the center of the action because he is the one who carries out the active work to build his significant learning that leads him to solve real, complex problems that affect him or society and the world. This didactic strategy promotes curiosity and strengthens interest in research in students, through the development of skills such as information management, oral and written expression in both Spanish and English, to carry out autonomous learning, learn to work alone, investigating and integrating one's own knowledge, but also collaborative work in interdisciplinary work teams with their classmates or from other technical

careers, as well as with the teachers who teach the different subjects, this in order to apply and integrate their new and previous knowledge in the resolution of current problems such as food and water supply, pollution, tree care, carbon footprint, among others [15].

By researching, students learn to perform complex tasks and develop superior mental capacities such as information management in which they must search, critical analysis and synthesis, thus developing critical and systematic thinking, in addition to strengthening commitment, respect, patience, tolerance and responsibility when working in a team [11]. In this work, the students had to solve a current problem using PBL, in a sustainable issue such as food production, considering the poverty of nutrients and soil erosion, in the pollution of land, water and air, which affects humanity and leads to the extinction of species of flora and fauna. Currently it is necessary to take actions aimed at reducing or nullifying the damage that man does to the environment with his daily activity and the development of technology [16]. The aims of this work were to apply project-based learning to design a sustainable garden that uses renewable energies, help the environment and raise awareness of the care of the planet through environmental education with PBL.

2) Methodology:

The Sustainable Energy Technician is the technical professional prepared in sustainable aspects for the care of the environment, as well as to use, install and repair solar energy systems to contribute to the sustainable development of their environment. The institution prepares them with knowledge and gives tools so that they can join the labor and professional field of the country. The students work with photocell that is an electronic device that produces an electrical current when exposed to sunlight, this can be enough to light a lamp or provide enough voltage to recharge a battery. A solar panel is made of multiple photocells. It can be composed of germanium, gallium, silicon and phosphorus mainly [17].

The PBL was carried out in this research in a group of 60 students who were in the second level of bachelor degree of the Center for Scientific and Technological Studies No. 11 "Wilfrido Massieu" (CECYT11), of the Sustainable Energy Technician (SET) career. They were organized into collaborative work teams, in the subject of Chemistry in which they review energy manifestations, the periodic table and all the metals that can serve as material to build photocells as application in their technical career. It is necessary to apply didactic strategies such as PBL and design activities that develop their curiosity, motivate and interest them.

The teams were asked to carry out documentary research about of sustainable gardens, like this the students designed a sustainable garden in the school, for the cultivation of vegetables, medicinal or ornamental plants considering factors such as: exposure to solar radiation, the production of carbon dioxide that has an energy cost, in addition to the geographical location, the type of crop, its management, the need for nutrients, type of soil, water supply through irrigation. Previously, the students investigated what factors need to be known and controlled in a sustainable garden. They found that these factors are:

1. Wind direction is a function of the geographical orientation in which the crop is located, while the wind speed must be considered to know the ventilation rate of the orchard.
2. Precipitation according to the time of year.
3. Moisture, the water that plants absorb is transpired by the stomata, and released into the atmosphere, this moisture is "charged" with heat "energy" (temperature), which helps the development of plants.
4. Solar radiation is the factor that moves other factors to greater radiation, higher temperature, lower relative humidity, air movement, convection of air currents, among other factors. Solar radiation is influenced by the seasons of the year and meteors such as cloudiness.
5. Temperature, important in the cultivation of plants inside the greenhouse or in the open air.
6. Fertilization can be of two types: water and mineral. Water and mineral fertilization is done through hydroponics solution or the use of solid fertilizers [6].

In a sustainable garden, all the parameters that influence the growth of plant crops must be monitored, such as: water supply, relative humidity, temperature, solar radiation, ventilation and fertilizer supply, this to have the best yield and quality of the crops.

The life of plants, their growth and nutrition are directly related to water, so it is important to study hydraulics, which is the behavior of liquids and their particular properties studied by physics. The garden container can be PVC vertical or in plastic bags, growing tables, planters or pots depending on the space for it.

The subject of mathematics helped to carry out a study of the shadow cast by the sun and to know its inclination during the winter taking as a reference the equator of the earth and the location of the solar panel, because it is the time of year with the less sunlight in Mexico City.

Chemistry allowed them to know how a photocell is chemically composed, the characteristics of the elements that compose it, as well as the chemical composition of the fertilizers that would be used for the cultivation of plants.

Results:

The figure 1 shows the model of a horizontal garden with PVC tube where the plants are located and is supplied with nutrients from hydroponic solution that is distributed with a pump that receives electrical energy from a photocell.

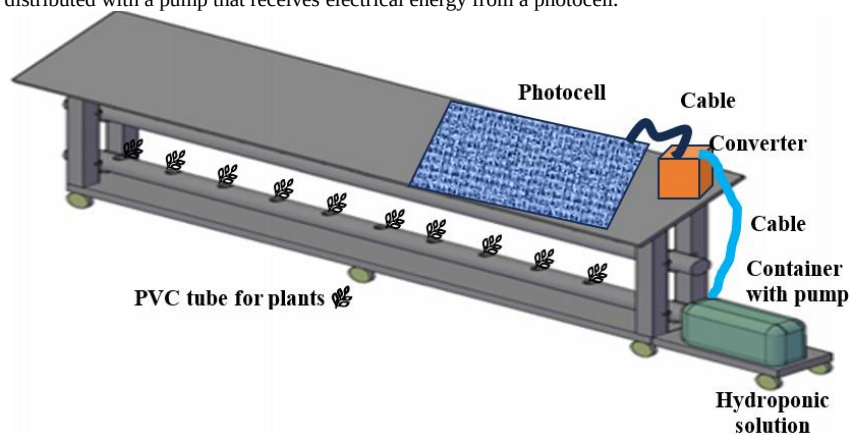


Figure 1. Model of sustainable garden

The figure shows the design of the horizontal garden supplied with nutrients and energy.

Source: Own elaboration (2025).

Plants use the chemical elements present in the soil or in hydroponic solutions and transform them through various biochemical processes that take place within the plant, into products that can be used by man. When photosynthesizing, chlorophyll in plants captures energy from sunlight and converts it into chemical energy that they store in molecules such as glucose and adenosine triphosphate (ATP). The process is carried out on the chloroplasts of the leaves. The essential chemical elements that plants need to develop their biological activity are: carbon (C), oxygen (O), hydrogen (H) that they take from water and air. It also requires macroelements necessary in relatively large quantities such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) and the microelements that the plant needs in small quantities such as boron (B), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) [18]. Nitrogen improves its foliage, and the development of the plant is an important part of the protein structure, phosphorus is an important part of ATP and favors the preservation of the fruit. Potassium participates in the ion exchange of the plant, magnesium is an important part of chlorophyll, iron is an electron carrier, as a cofactor and responsible for the green color of plants, while boron participates in three important processes for the plant, as a cofactor in metabolic activity, in addition to maintaining the structure of the wall and the functions of the cell membrane [19]. The students proposed that all these nutrients be in the soil and hydroponic solution. The proposed plants for sustainable gardening were strawberries, chamomiles, lettuce, tomatoes and parsley.

4. Discussion:

Beyond the use of word sustainability or sustainability, society must actively participate in the care of the environment, make good use of natural resources and carry out actions to avoid or reduce the pollution that occurs due to the daily activity of man and the scientific and technological progress of man, which is why environmental education is necessary. Environmental education must be holistic, integrating knowledge of the environment and different disciplines such as ecology, physics, chemistry, biology, mathematics, economics, sociology, philosophy, just to mention a few, but also the competencies of the individual must be considered, so that they lead them to propose, design, carry out and promote actions and instruments to take care of themselves and the planet. In addition to reduce or avoid the deterioration of the land. The IPN promotes the training of professionals who develop science and technology and who are committed to caring for the environment and participate in research projects for solve problems of importance to the country in the field of engineering, medicine and society. For this, students must start when they are bachelor degree in technology, applying their previous knowledge and that they acquired in the classroom, skills, attitudes and values depending on the technical career that they are studying. The Institute develops and strengthens soft skills in students, as collaborative work teams and their capacity for analysis, critical judgment, management information, so that they learn to express themselves orally and in writing, to make decisions and leadership. The project-based learning allows students to interact in different face-to-face or virtual learning environments through the use of ICTs, so that they achieve the investigative skill, necessary for the profession, society and life [20], [21].

In project-based research at the technical bachelor degree is a teaching strategy throughout a course which requires knowledge and application of the scientific method, to carry out work in a planned and orderly manner university level. In this work, research was promoted among students, to induce and motivate them to make proposals in which they apply and integrate their technical knowledge to design a sustainable garden [22].

PBL is an active strategy that allows students to learn, innovate, reflect, analyze, propose, and work collaboratively, observe, thus preparing for life and the profession [11], [13]. After the documentary research, the students acquired various knowledge about the sustainable garden and how it can be carried out, once they know what its components, requirements and operation are.

The students needed research on topics such as photosynthesis, the chemical compounds that the garden needs and the agrochemicals used to reduce, control and eradicate a pest that damages crops, as well as the type of irrigation. In addition, research was carried out on the operation of a photocell and how to transform solar energy into electricity to save energy that the garden will use.

The construction of the sustainable garden will be put into practice in other school year.

5. Conclusions: Environmental education must be seen with a multidimensional and interdisciplinary, holistic approach whose objective is to form citizens who are aware, informed and committed to caring for the environment. Students require theoretical and practical knowledge that allows them to solve current environmental problems, such as sustainable gardens that provide food and support the care of the environment without using fertilizers. The actions that are carried out to take care of the environment and at the same time use natural resources in a sustainable way must be carried out from an ethical point of view, with respect, tolerance among other values. The people, government, schools and product manufacturers must actively participate in these actions.

Sustainable school gardens develop creativity, curiosity and innovation among the students who participate in their creation and allow them to become aware of the importance of caring for the environment, patience, the ability to observe, responsibility, collaborative work, discipline and enjoy nature.

The APB allowed students to develop the ability to learn autonomously and collaborative work teams for the resolution of real problem like the food supply and to facilitate meaningful learning, where the integration of theoretical and practical knowledge is required, preparing students for life and profession, while strengthening their interest in research, reflection, critical thinking, their ability to communicate and use technology.

The IPN promotes research among students and helps them develop their creativity, scientific participation and technological innovation whit small project that it make think and develop conscience environmental.

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8) Data Availability: The data that supports the findings of this study are available in this paper.

9) Conflict of interest: The author declares that there is no conflict of interest.

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Biography: Maria Guadalupe Rodríguez Angeles, research professor of Chemistry in bachelor degree with 35 years of experience in the classroom and laboratory. She participated in the creation of the new Technical Career in Sustainable Energy at the IPN, she belongs to the school sustainability committee and the Educational Innovation and Research Network at the IPN and National System of Researchers.