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Balancing CO_2 in the School Campus: A Strategic Entry for Greening School Communities

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ABSTRACT: As anthropogenic carbon dioxide is being singled out as one of the culprits of global warming and climate change, there is an urgent need to increase and maintain vegetation and to educate the young generation about low carbon dioxide science economy, which will pave the way for a greener and more sustainable community. This paper describes two-fold activities, which are the learning process and the learning content (scientific). The learning process dealt on a problem/project-based learning approach developed by teachers in pilot project sites which focused on the integration approaches across curricula in the context of real-life scientific issues. The learning content, on the other hand, focused on calculation of carbon dioxide and other pollutants sequestration by trees. An experiential and discovery learning approach is a significant driver for shifting one's perspectives and helps to develop responsible citizens who can manage a more sustaining environment.

Keywords: GHGs, sequestration, experiential and discovery learning

Introduction

Energy consumption of school campuses have dramatically increased, caused primarily by modernization of school facilities such as computerization programmes, which aim to enhance the 21st century skills of students so that by the time they join the 21st century labour force they can cope with the demands of the labour market. As technological modernization continues, the education landscape drastically changes, transforming into a more energy-based learning process. Though we may claim that an energy-driven learning process offers good benefits, we leave behind its carbon footprint unnoticed. An average of 0.4–0.7 kg of carbon dioxide (CO_2) is emitted for every kilowatt hour of electricity consumption depending on the fuel used to produce such energy. Our learning system has failed to provide learning activities that reveals to our students and teachers how much CO_2 exactly is emitted on a daily basis. It is a well-known fact that the main culprit of global warming is the build-up of greenhouse gases (GHGs) in the atmosphere and CO_2 occupies the largest parts per million (PPM).

Although schools have increased their carbon footprint, there are still opportunities to balance it out. Schools usually have considerable land area but only about 50–60% are utilized for buildings, pavements, and open grounds, while the rest is used for perhaps landscaping or forest gardens. Open playgrounds can absorb CO_2 and other GHGs but the exact figure is still uncertain.

Discovering the fact that trees play an important role in balancing CO_2 storage and emission through experiential learning is something that students and teachers will not forget for a lifetime. Identifying a species of tree, as a woody plant that has many secondary branches supported clear of the ground on a single main stem or trunk with clear apical dominance, is primarily the work of the biology students under the leadership of a science teacher. Measuring the diameter at breast height (DBH) of a tree is the work of the same group of students guided by a mathematics teacher, while interpreting the scientific implication of the investigation is usually done by students guided by the science, mathematics and even economics teachers.

HIGHLIGHTS

- Students and teachers came to realize when electronic machines and electrical appliances are run, energy is utilized and anthropogenic CO_2 is emitted. They also learned how CO_2 builds up in the atmosphere and causes the greenhouse effect.
- Through integrated learning, teachers and students understand that photosynthesis is not simply about absorbing CO_2 and releasing oxygen but rather it has a significant role in balancing ecological systems.
- Students and teachers learned that about 0.4–0.7 kg of CO_2 is emitted for every kilowatt hour of electricity depending on the fuel used to produce such energy.
- Students learned about theeconomic, environmental, and social benefits of trees, and discovered common species endemic to their locality.
- Students enhanced their mathematical skills by measuring tree DBH and calculating CO_2 absorbed, O_2 released and removal of other pollutants.
- Given the monthly electrical consumption bill, students calculated the amount of CO_2 produced and correspondingly determined the number of trees needed to sequester such amount of CO_2.
- With the understanding of carbon footprinting and sequestration, students and teachers could be a potent force to initiate green projects in their communities, such as tree planting, seedling culture, adopt-a-park or hill, establish partnerships with GOs and NGOs to create public awareness and tangible actions towards a sustainable environment.

Benefits and Values of Trees

Students need to discover and experience that trees absorb CO_2 from the atmosphere and release oxygen in the process of photosynthesis whereby technically reducing the CO_2 build-up in the atmosphere. Furthermore, trees remove gaseous pollutants by absorbing them with normal air components through the stomata in the leaf. Some of the other major air pollutants are sulphur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO_x), and small particulates. Trees act as natural pollution filters. Their canopies, trunks, roots, and associated soil and other natural elements of the landscape filter polluted particulate matter out of the flow toward the storm sewers. Reducing the flow of storm water reduces the amount of pollution that is washed into a drainage area. Trees use nutrients like nitrogen, phosphorus, and potassium, by-products of urban living, which can pollute streams. The most important ecological function of trees is protecting the land against erosion, the washing away of topsoil due to wind and water. The trunks and branches of trees provide protection from the wind, and tree roots help solidify soil in times of heavy rain. They help cool down the temperature during summer thus reducing the use of air conditioners and energy. In addition, trees and forests store water reserves that act as buffers for the ecosystem during periods of drought. So, this article presents how the researchers provide the technical support; monitor the teachers' learning journey and experience on the process of balancing CO_2 in the school campus.

Objectives

The study itself aimed to:

- Audit school's energy consumption against CO_2 emission and sequestration by trees through a school-based student learning project;
- Demonstrate development of computational skills among students in calculating the amount of CO_2 sequestered, oxygen released and other pollutants removed by trees; and
- Describe how this energy auditing learning project can trigger and push for green initiatives in the school and in the community.

Methodology

The study involved the following activities: (a) gathering energy consumption information, (b) identifying tree species, and (c) measuring the DBH.

The data on the schools energy consumption from the calendar year 2011 was obtained, upon request, from the power provider office. Students, guided by teachers, were able to convert the energy consumption in kWh per unit to CO_2 equivalent per unit.

Species were identified during the ocular survey. Each species was described at the species level. Plant characteristics such as inflorescence, colour and shape of leaves and root systems were noted to help in the identification process (Medecilo et al., 2007).

The DBH of trees was determined using a tape measure and was expressed in centimetres. The measurement of the DBH was taken at 1.3 metres above ground. Data gathering was conducted from April to May 2012. The sites were located at a forest park and at the perimeter inside the school campus as shown in Figures 1 and 2.

Results and Discussion

Table 1 shows how much energy is consumed by 1,300 students and 96 teachers and staff and its equivalent CO_2 emission. The total kWh energy consumption was 37,203 in one year (2011) multiplied by its factor of 0.7 kg/kWh of CO_2 since the electricity was produced by a machine fuelled by diesel (http://timeforchange.org). Therefore, the total CO_2 emission in one year alone is equivalent to 26,042.10 kg or roughly 26 tonnes.

Table 2 shows that Secondary School that has a total of 826 planted trees with an average DBH of 44.6 cm capable of absorbing about 5,014.80 kg of CO_2, 113.486 kg of other pollutants and with a released volume of oxygen amounting to 6,951.10 kg.

From the total energy consumption of 37,203.00 kWh by 1,300 students and 96 teachers and staff 26,042.10 kg of CO_2 is produced from 826 trees, capable of

Table 1. Secondary school energy consumption for 2011

Bill No.	Period	Amount (Peso)	Energy (kWh)	*CO_2 emission (kg)
5699873	1/1/2011	18,920.78	2,300.00	1,610.00
5883746	1/2/2011	763.43	83.00	58.10
6068607	1/3/2011	40,486.27	4,900.00	3,430.00
6170888	1/4/2011	14,329.22	1,600.00	1,120.00
6237451	1/5/2011	11,082.06	1,280.00	896.00
6371595	1/6/2011	25,601.85	2,980.00	2,086.00
6502438	1/7/2011	35,664.6	4,080.00	2,856.00
6485528	1/8/2011	25,683.98	3,040.00	2,128.00
6644267	1/9/2011	33,215.89	3,680.00	2,576.00
6753376	1/10/2011	30,435.78	3,520.00	2,464.00
6875502	1/11/2011	59,050.44	6,500.00	4,550.00
6990388	1/12/2011	30,643.59	3,240.00	2,268.00
TOTAL		325,877.89	**37,203.00**	**26,042.10**

* For diesel fuelled power grid, conversion factor is 0.7; http://timeforchange.org/offline-carbon-footprint-calculator

Figures 1 & 2. Students measuring tree trunk circumference to calculate diameter and determine how much CO_2 can be absorbed or sequestered

sequestering about 5,014.8 kg CO_2 from the atmosphere. Thus, about 21,027.30 kg of CO_2 still remains in the atmosphere (Table 3). More trees should be planted and more green spots created inside the school campus to help sequester CO_2.

Conclusions

The school-based CO_2 sequestration learning project provided an avenue, space and real-time reflection, not only for the students but for the teachers as well; as most of the teachers remarked that they didn't know anything about it until the project was implemented.

The activity showed that CO_2 balance through sequestration can be investigated, researched, learned and integrated into the learning system. It was also observed that hands-on activities provided an opportunity for students to undertake self-learning processes by engaging in real issues that matter to their real-life experience.

Based on the analysis conducted by the teachers and students in science and mathematics, from the data that the students have gathered, the 826 trees with an average diameter of 44.6 cm were not enough to absorb the 26 tonnes of CO_2 emitted due to power consumption in the school for one year (Table 1) and more forest or fruit trees are needed, thus planting of trees are rationalized, not just for scholastic requirement.

Recommendation

Schools need to develop a strategic plan

Table 2. Total number of trees by species and their diameter at breast height (DBH). Amount of CO_2 absorbed, amount of oxygen released and other pollutants removed (kg/yr)

Name	Number of trees	**Average DBH (cm)	*CO_2 sequestered by trees (kg)	*Oxygen eleased by trees (kg)	*Pollutants removed by trees (kg)
Mahogany	603	9.55	2,653.20	1,748.70	12.663
Mabolo	53	29.18	498.20	1,197.80	8.798
Gemelina	41	25.81	385.40	926.60	6.806
Narra	8	69.39	276.80	728.80	8.000
Ipil-ipil	57	8.00	57.00	165.30	57.000
New Guinea labula	33	26.06	310.20	745.80	5.478
Mango	13	51.33	248.30	592.80	5.538
Talisay	13	26.62	122.20	293.80	2.158
Rubber Tree	5	155.47	463.50	551.50	7.045
TOTAL	826	44.60	5,014.80	6,951.10	113.486

* Nowak, 1994 and Nowak et al., 2007

** Actual measurement done by the students (tree circumference at breast height or 1.3 m above the ground)

Energy consumption (kWh)	*Equivalent CO_2 (kg)	Total No. of trees in school campus	Total equivalent CO_2 sequestered by trees (kg)	Excess CO_2 not sequestered by trees (kg)
37,203.00	26,042.10	826	5,014.80	21,027.30

Table 3. Summary of balancing CO_2 in school for energy consumption with diesel as fuel for the power plant

to increase the awareness of teachers, students and the school-community about levels of CO_2 they are emitting; as well as action plans to reduce CO_2 emission and power consumption by using energy-efficient facilities. It is recommended that the idea of carbon footprint be integrated not only in science and mathematics, but across the school curriculum. One of the most practical and scientific approaches to sequestering CO_2 on school campuses is to plant more trees.

Education Ministries could create a policy for all schools to monitor their carbon footprint through energy consumption and CO_2 emission so they can develop alternative plans or curricula that integrates climate change issues and considers the planting of trees, flowers, vegetables and any other kinds of vegetation that absorbs CO_2.

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