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 CO₂ 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 CO₂ and other GHGs but the exact figure is still uncertain.

Discovering the fact that trees play an important role in balancing CO₂ 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.

Benefits and Values of Trees

Students need to discover and experience that trees absorb CO₂ from the atmosphere and release oxygen in the process of photosynthesis whereby technically reducing the CO₂ 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 (SO₂), ozone (O₃), nitrogen oxides (NOₓ), 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 CO₂ in the school campus.
Objectives

The study itself aimed to:
- Audit school’s energy consumption against CO\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{2} since the electricity was produced by a machine fuelled by diesel (http://timeforchange.org). Therefore, the total CO\textsubscript{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\textsubscript{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\textsubscript{2} is produced from 826 trees, capable of

<table>
<thead>
<tr>
<th>Bill No.</th>
<th>Period</th>
<th>Amount (Peso)</th>
<th>Energy (kWh)</th>
<th>*CO\textsubscript{2} emission (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5699873</td>
<td>1/1/2011</td>
<td>18,920.78</td>
<td>2,300.00</td>
<td>1,610.00</td>
</tr>
<tr>
<td>5883746</td>
<td>1/2/2011</td>
<td>763.43</td>
<td>83.00</td>
<td>58.10</td>
</tr>
<tr>
<td>6068607</td>
<td>1/3/2011</td>
<td>40,486.27</td>
<td>4,900.00</td>
<td>3,430.00</td>
</tr>
<tr>
<td>6170888</td>
<td>1/4/2011</td>
<td>14,329.22</td>
<td>1,600.00</td>
<td>1,120.00</td>
</tr>
<tr>
<td>6237451</td>
<td>1/5/2011</td>
<td>11,082.06</td>
<td>1,280.00</td>
<td>896.00</td>
</tr>
<tr>
<td>6371595</td>
<td>1/6/2011</td>
<td>25,601.85</td>
<td>2,980.00</td>
<td>2,086.00</td>
</tr>
<tr>
<td>6502438</td>
<td>1/7/2011</td>
<td>35,664.6</td>
<td>4,080.00</td>
<td>2,856.00</td>
</tr>
<tr>
<td>6485528</td>
<td>1/8/2011</td>
<td>25,683.98</td>
<td>3,040.00</td>
<td>2,128.00</td>
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<tr>
<td>6644267</td>
<td>1/9/2011</td>
<td>33,215.89</td>
<td>3,680.00</td>
<td>2,576.00</td>
</tr>
<tr>
<td>6753376</td>
<td>1/10/2011</td>
<td>30,435.78</td>
<td>3,520.00</td>
<td>2,464.00</td>
</tr>
<tr>
<td>6875502</td>
<td>1/11/2011</td>
<td>59,050.44</td>
<td>6,500.00</td>
<td>4,550.00</td>
</tr>
<tr>
<td>6990388</td>
<td>1/12/2011</td>
<td>30,643.59</td>
<td>3,240.00</td>
<td>2,268.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>325,877.89</td>
<td>37,203.00</td>
<td>26,042.10</td>
</tr>
</tbody>
</table>
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 to create more greener spots where students and teachers can be engaged in real issues that matter to their real-life experience.

**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)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of trees</th>
<th><strong>DBH (cm)</strong></th>
<th>*CO$_2$ sequestered by trees (kg)</th>
<th>*Oxygen released by trees (kg)</th>
<th>*Pollutants removed by trees (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahogany</td>
<td>603</td>
<td>9.55</td>
<td>2,653.20</td>
<td>1,748.70</td>
<td>12.663</td>
</tr>
<tr>
<td>Mabolo</td>
<td>53</td>
<td>29.18</td>
<td>498.20</td>
<td>1,197.80</td>
<td>8.798</td>
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<tr>
<td>Gemelina</td>
<td>41</td>
<td>25.81</td>
<td>385.40</td>
<td>926.60</td>
<td>6.806</td>
</tr>
<tr>
<td>Narra</td>
<td>8</td>
<td>69.39</td>
<td>276.80</td>
<td>728.80</td>
<td>8.000</td>
</tr>
<tr>
<td>Ipil-ipil</td>
<td>57</td>
<td>8.00</td>
<td>57.00</td>
<td>165.30</td>
<td>57.000</td>
</tr>
<tr>
<td>New Guinea labula</td>
<td>33</td>
<td>26.06</td>
<td>310.20</td>
<td>745.80</td>
<td>5.478</td>
</tr>
<tr>
<td>Mango</td>
<td>13</td>
<td>51.33</td>
<td>248.30</td>
<td>592.80</td>
<td>5.538</td>
</tr>
<tr>
<td>Talisay</td>
<td>13</td>
<td>26.62</td>
<td>122.20</td>
<td>293.80</td>
<td>2.158</td>
</tr>
<tr>
<td>Rubber Tree</td>
<td>5</td>
<td>155.47</td>
<td>463.50</td>
<td>551.50</td>
<td>7.045</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>826</strong></td>
<td><strong>44.60</strong></td>
<td><strong>5,014.80</strong></td>
<td><strong>6,951.10</strong></td>
<td><strong>113.486</strong></td>
</tr>
</tbody>
</table>

*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)**
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$_2$.

**References**


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**Table 3. Summary of balancing CO$_2$ in school for energy consumption with diesel as fuel for the power plant**

<table>
<thead>
<tr>
<th>Energy consumption (kWh)</th>
<th><em>Equivalent CO$_2$ (kg)</em></th>
<th>Total No. of trees in school campus</th>
<th>Total equivalent CO$_2$ sequestered by trees (kg)</th>
<th>Excess CO$_2$ not sequestered by trees (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37,203.00</td>
<td>26,042.10</td>
<td>826</td>
<td>5,014.80</td>
<td>21,027.30</td>
</tr>
</tbody>
</table>