Environmental Science Practice at Miyagy University of Education

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Abstract: A field-based practice of Environmental Science was conducted at Miyagi University of Education, in which students used the Scientific method to answer questions related to the environment. Students assessed various environmental variables such as temperature, noise, forest structure, and the environmental impact of dumping sites. These variables were assessed within the university campus and at Aoba no Mori, a protected forest patch that surrounds the university. By projecting experiences in the field to a global scenario students were able to have a better understanding of current environmental problems such as the biodiversity crisis, global warming, and contamination of the environment.

Keywords: Environmental Science, temperature, biodiversity, ecosystem quality, noise, and environmental impact

1. Introduction

Environmental Science is a multidisciplinary academic field focused on the relationship between humans and the environment (Pfafflin and Ziegler, 2006). For many practical reasons, its inclusion in the school curriculum is important to help students understand their role in the human-environment interaction, and foster the formation of environmentally educated citizens (Orr, 2004; Golub, 2006; Jacobson *et al*., 2007). During the past few decades, many schools worldwide have incorporated this field of enquiry into their curriculum, and full university departments has been created for it. However, there are many resources from which it is possible to learn about Environmental Science without actually practicing it, as there are lots of information about the field in the internet.

Classroom-based teaching, although important to help student assimilate facts and figures, may not be as effective as experimental and field-based teaching where students apply learnt knowledge to answer scientific questions about the environment (Jacobson *et al*., 2007). In this paper, we explain an experience in this regard, hoping that it will encourage other teachers to get out of the classroom and teach students in a more effective way by practicing Environmental Science as scientists do.

2. Methods

In a school semester of 15 classes, all of which were concentrated at the end in a 4 days, intensive course, students received a 90 minutes (1 class) introduction during which they learned the importance and basics of the scientific method and Environmental science. The course exercise was divided in 5 different activities (4 of which are explained in this paper). These activities started with the elaboration of a question in an environmental topic. The students were requested to start with one or various hypotheses that could potentially be answers to these questions, and continued with their field work, out of the classroom, where they took relevant data to answer these questions. This approach resemble the process of ecological inquiry, which involves the following steps: (1) the generation of questions through observation and exploration,

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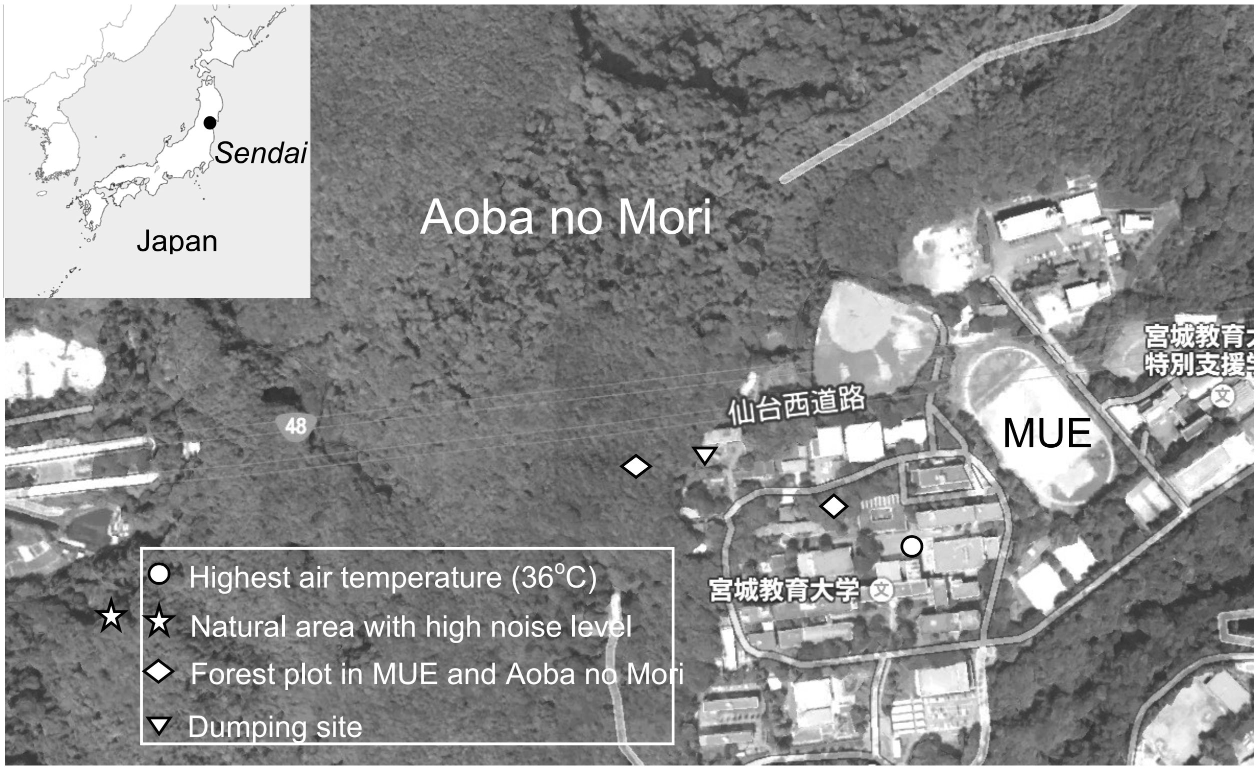

Figure 1: Map of sites where students did their experiments in Miyagi University of Education (MUE), and Aoba no Mori, Sendai City, Japan. For simplicity, only sites that students found relevant to answer their questions are shown.

(2) the development of ideas about the answers to those questions, (3) the evaluation of competing possible answers through systematic observation and experiments, (4) the drawing of an inference about the natural world (Ricklefs and Miller, 2000).

Many of the methods to gather data were variations made by the students based on explanations made by the teacher. Some methods might not be exact, but still they are a good approximation to what environmental scientist do. As a consequence, quoting authors on the kind of methodology used here has been nearly impossible. Therefore, emphasis is on the fact that students learn by gathering and analyzing data rather than an exact method of data gathering.

The topics considered for this experience were as follows: global warming, noise, biodiversity (not discussed in this paper), forest structure, and environmental impact of dumping sites. Students were divided into groups and performed all activities cooperatively with their group members.

Explanation of the activities

I. *Global warming*: Global *warming* is one of the most current environmental problems, experienced by all almost everyday (Pfafflin and Ziegler, 2006). We aimed at understanding our planet's capacity to absorb heat on daily basis, and how this is connected to the climate and global warming. For this activity, students were asked the following two questions:

Question 1: Which one absorbs heat faster, the land or the sea?

Students' hypothesis: the sea absorbs heat faster.

Experiment to answer this question: two paper cups, one with soil and another with water, were prepared and put outside under the sun (NASA, non dated). The temperature in each of these two cups was measured every 2 minutes for as long as 40 minutes. If the students' hypothesis is true, the cup with water would show a faster increase in temperature.

Question 2: Where is the air temperature higher, in forested areas or in the cities?

Students hypothesis: air temperature is higher in the cities.

Experiment to answer this question: students measured the air temperature in 9 sites within the university campus and at Aoba no Mori, some of which were purely concrete and asphalt sites, thus resembling cities, and some covered by trees, resembling a forest (Figure 1).

II. *Noise*: Noise, defined as unwanted sound, including sound generated as a byproduct of other activities such as transportation and industrial operations, is one of our greatest problems (Pfafflin and Ziegler, 2006). With this activity we aimed at teaching students about two issues, noise awareness, and sound contamination (Echenique-Diaz and Saito, 2013).

Question: Which places are the noisiest around Miyagi University of Education?

Students hypothesis: only around the entrance where many passing cars can be heard.

Experiment to answer this question: Students were asked to perform a 1 minute sound recording and define which sound was the loudest, an artificial sound (produced by human activities) or a natural sound, and define which one they considered as noise. Students chose to do the recordings in two sites within the university campus, the Library, supposedly a very quiet place, and near the entrance, close to a road. Another 3 sites were placed within Aoba no Mori (Figure 2).

III. *Forest structure*: Learning the difference between a pristine forest, a secondary one, and a plantation is important to understand concepts such as ecosystem quality and ecological services (Bond, 1998; Orr, 2004). Here we aimed at assessing the structure of different forest patches of the same vegetation type, to learn about the effect of human activities such unplanned logging and deforestation, and their ecological consequences.

Question: What are the differences between forest patches in terms of forest structure, in Miyagi University of Education and at Aoba no Mori?

Students hypothesis: forest patches in Aoba no Mori resemble the structure of an original forest, while those at the university campus resemble the structure of a secondary forest.

Experiment to answer this question: a 10 x 10 meters plot was set in a forested area of the university campus and one inside Aoba no Mori (Cornell University and Penn State University, 2009). Within each plot students measured the circumference of the mast at breast height for each tree higher than 4 meters. Students also counted the number of trees with a diameter larger than 15 cm in the plot and extrapolated that number to one hectare to get a density estimate (trees per hectare). Canopy cover was measured with a spoon with the convex side up and two lines drawn perpendicularly. These lines in the spoon made possible to measure the canopy at 10 different random spots within the plot. The foliage reflected in the spoon was counted as an approximate percentage depending on how much they filled the 4 areas defined by the lines in the spoon.

IV. *Environmental impact of dumping sites*: In almost every society through human history, unwanted materials tended to accumulate in specific points around settlements. This is as true today as it was thousands of

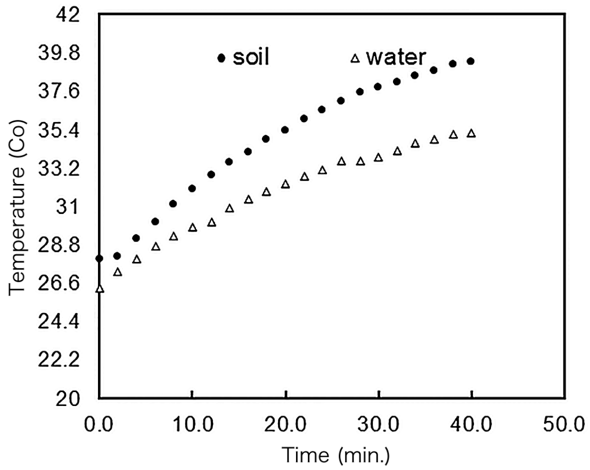

Figure 2: Heat absorption by soil and water.

years ago. Without proper management, these dumping sites pose a threat to the environment (Dresnack, 2006). In this exercise we aimed at teaching students to evaluate the potential impact that disposed items around the university campus pose to the environment. Students used a qualitative approach to easily assess the potential impact of as many objects as possible in the dumping site, based on their background knowledge and experience.

Question: In a scale of 0 to 100, where 0 means no environmental impact and 100 means irreversible environmental impact, how large is the impact to the environment in dumping sites around the university campus?

Students hypothesis: the impact to the environment posed by dumping sites around the university is less than 20 in a scale of 0 to 100.

Experiment to answer this question: students evaluated 3 dumping sites within the university. One dumping site was next to the students' club house, and therefore it is safe to asume that items there were disposed by the students themselves. The other two sites were next to university departments, and items there had been disposed by the university staff.

The following criteria were used to score items in these sites in the scale shown before:

1- Time since it was thrown: by looking at the state of corrosion and/or degradation, it is possible to relatively assess how long have items in the site been abandoned in terms of weeks, months or years. The longest the time since disposal, the highest the score.

2- Pollution risk: some objects are more aggressive to the environment than others. However, all items foreign to a particular area can be pollutants (Dresnack, 2006). The higher the pollution risk, the higher the score. For instance, students considered paper and wood to be less aggressive to the environment than plastic, glass, and metallic components at the site. Similarly, oil and other pollutants were ranked to pose the highest risk, hence the highest score.

3- Danger to wildlife: all wildlife was considered, from plans and invertebrates to more noticeable animals such as birds, frogs and mammals. Students evaluated how the materials in the site may affect local plants and animals. The higher the risk to wildlife, the higher the score.

4- Risk to human health: risk to human health was considered from that posed locally by the site (accumulation of pests, chemical fumes, risk of injury) and by that posed by contaminating the water that drains superficially and eventually gets to rivers (Salvato, 2006).

5- Scale of impact: students evaluated how large was the dumping site and its potential damage to the environment. The larger the site, the larger the damage and the score.

6- Visual impact: the view of dumping sites can create visually negative images about the university, affecting people's emotions towards the institution. In this case, the more visually obvious sites would be ranked with

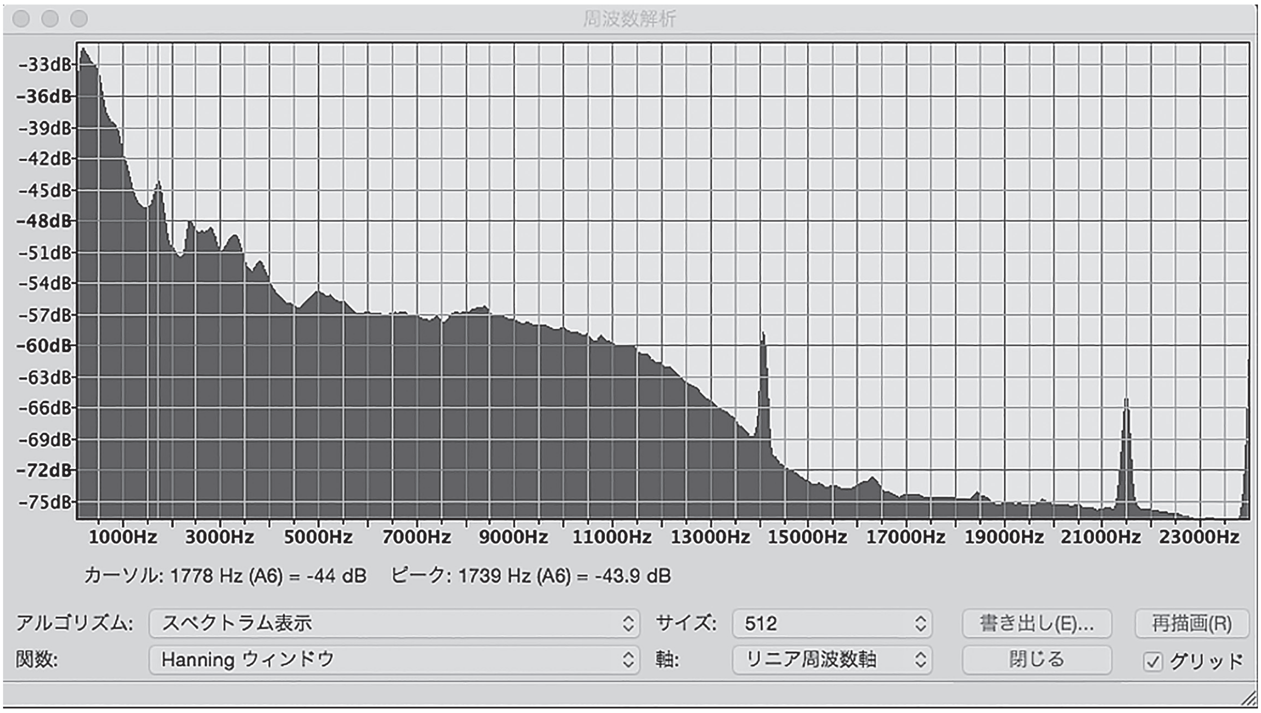

Figure 3: Plot spectrum of the sound recorded at the Library of MUE. Note the intensity of the sound of air conditioning inside the building, a place that most people consider “quiet”. This sound was classified by the students as “noise”.

higher scores in the environmental damage scale.

7- Cost of recycling: students evaluated the potential economic cost of recycling objects and other materials in the dumping site. The higher the cost, the higher the score.

8- Site restoration: students evaluated the potential economic cost of restoring the area were the dumping site is to natural conditions. The higher the cost, the higher the score.

Scores given at criteria 1 to 8 were averaged and that number was taken as the value of environmental impact in the 100 points scale. This value, although very relative and useful only for comparison made by this method, was enough to let the students consider a variety of angles from which they could appreciate the magnitude of impacts to the environment.

3. Results and Discussions

Throughout these activities, students engaged in discussions and extrapolated their results to a global scenario, frequently recalling the usefulness of the scientific method. All the students that participated in this exercise (4 in total) were junior and senior college students, and although they had already passed many science subjects, they had no knowledge of the existence of the scientific method. Answering the questions they elaborated by experimenting, even though the methods were not strictly adequate, had helped them understand environmental science issues from a different perspective. The following are the students answers to their questions:

Global warming: contrary to the hypothesis, soil absorbed heat faster than water. This results from the water’s hight heat capacity, where it needs to absorb more heat than soil to raise a degree in temperature. As a consequence, the cup of soil exposed to the sun’s heat increased its temperature faster than the cup of water (Fig. 2). With this experiments students also understood why in coastal areas there is a difference in temperature between the land and the sea. Similarly, they understood that sea and ocean currents are the climate engine of the Earth. Given that water in the oceans will take longer to release the heat absorbed from the sun's radiation, they can transfer heat from the tropics to the cold areas to the north and south of the planet. Global warming can disrupt this climate engine by melting glaciers on the Earth poles. As the ice melts quickly, millions of cubic meters of cold fresh water will enter the sea, strongly disrupting the present movement of sea currents, hence affecting heat transfer from the tropical regions.

Students also found that the air temperature is higher at sites with humans constructions. The central square of MUE, next to the library, showed the highest air temperature (Fig. 1). In other sites, air temperature was lower, especially in points inside Aoba no Mori. Cities and urban areas contribute to reflect the sun's Infrared radiation, resulting in an increase of the air temperature. In very large cities such as Tokyo, the temperature can at times go above 40 degrees centigrade due to the combined reflective effect of its building and urban infrastructure.

Noise: students found two places, one within MUE and another at Aoba no Mori, that were perceived as "noisy" even though at first, they could not recognize them as such. The Library of MUE, a place that is usually considered "quiet", was considered as noisy by the students after they realized how the sound of air conditioning dominates the sound environment of the building. We may not pay attention to this sound as we are used to it. However, once you become conscious of it, and compare it to a more quiet place, its annoyance becomes obvious.

At Aoba no Mori, students found a site with well preserved vegetation in a small ravine. At this site they found species of frogs, snakes and heard the sound of many wild birds. In appearance, this was the closest to a pristine forest in Aoba no Mori. However, when analyzing

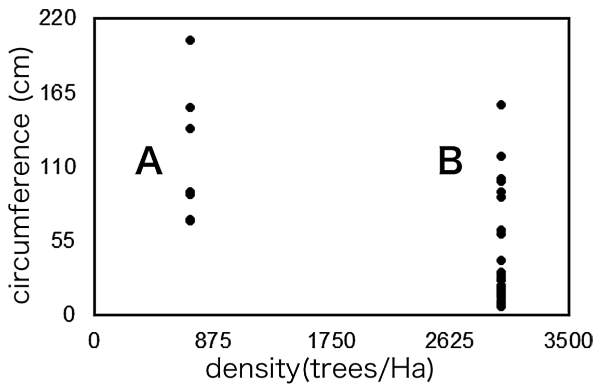

Figure 4. Difference in forest structure between A, a forested part of MUE, and B, Aoba no Mori.

the recording made at this site, they noticed that it was contaminated with the sounds of cars from the nearby expressway (Fig. 1). With this exercise students learnt to recognize noise as form of environmental contamination.

Forest structure: students found differences in forest structure between the plots measured at MUE and Aoba no Mori. All measured parameters were different. The canopy cover was smaller at MUE, with 65.5 % cover compared to the canopy at Aoba no Mori, with a 80.7 %. The mast circumference at breast height and the density of trees was also different (Fig. 4.). Their results indicated that the structure of the forest plot at Aoba no Mori resembles more that of an original forest, with a higher tree density. The circumference data for this plot showed many more trees of smaller size, indicating that tree regeneration is occurring, while on the contrary at the plot in MUE there is almost no regeneration, indicating a selective logging by the university staff. These results served the students to understand the effect that wood extraction can bear on a forest, changing its structure that in turns affect many of the ecological functions of this ecosystem.

Environmental impact of dumping sites: of the three sites evaluated, students found two that pose a risk to the environment over 50 % in the scale of 100 they have used (Fig. 5). The site next to the student's club house showed a 57 % score of potential environmental impact,

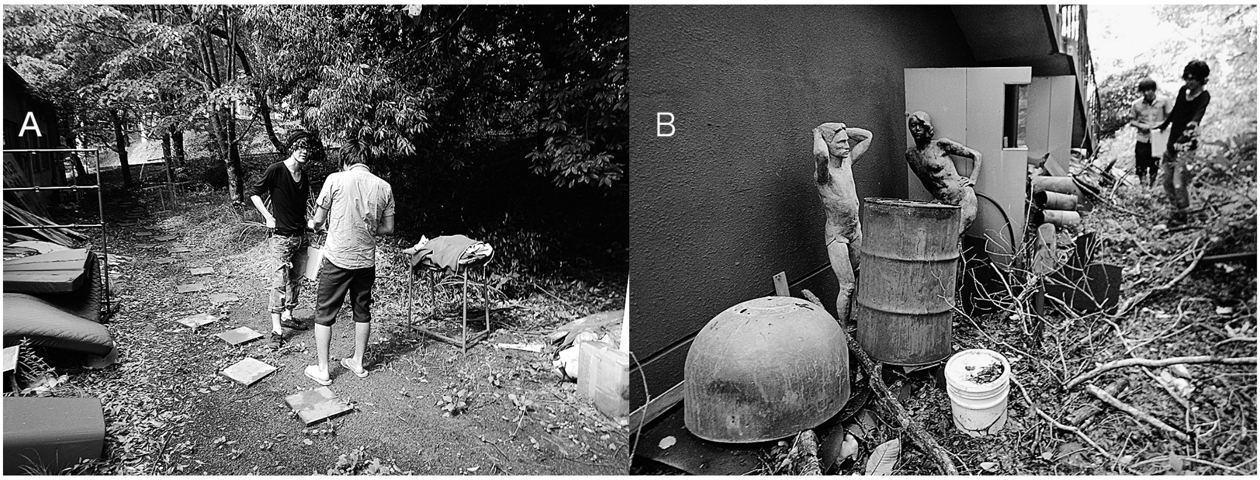

Figure 5: Dumping sites evaluated for environmental impact. A, students' club house. B, sculptures' workshop.

meaning that although it was not an irreversible impact, it posed serious threat to the environment. Most of the objects there were made of wood such as tables, chairs and cabinets, and of metals, such as bicycles, furniture frames and lockers. A few electronic items such as TV sets and other appliances were also dumped in the open. Most of the garbage found at this site had been exposed for at least several years, with some showing signs of intense decay, probably dumped there more than 5 years ago. Evaluating this site gave the students a perspective of the things they normally do around this club house and the effects their behavior has on the environment.

The dumping site around the sculptures' workshop, created mainly by the university staff working there, showed a score of 73 %. Items found here were mainly metallic ones, most on a state of advance corrosion. The scale of the dumping site was larger than that at the site next to the students' club house, and although it did not pose an irreversible impact to the environment, it was obviously a serious one in terms of the scale used by the students (Fig. 5). This site reflects a serious problem seen in many areas all across Japan, where people dispose things they don't need in places away from the public eye. It is not rare then to find objects such as old refrigerators and washing machines in otherwise pristine forests next to a road. Here, in a similar fashion, most of the objects are hidden by the building and therefore are not spotted by visitors to the workshop. Students' evaluation of this site gave them a perspective of the role that members of a society play in causing environmental damage, were even university professionals in an involuntary fashion contribute to the contamination of our surroundings.

4. Conclussions

The exercises described in this paper, although not completely accurate in terms of methodology, represent an alternative to teach student in a practical way the essentials of Environmental Science by means of the Scientific method. Students assimilated knowledge without having to commit to memory many of the current issues that affect the human-environment relationship, and reflected on the lessons learnt throughout this experience.

The scale of this study and the number of students was not large enough to evaluate its effect. However, the positive actitude of the students and their enthusiasm when carrying the field work attest to the effectiveness of using practical teaching methods. Our emphasis on not giving too much information to the students, while guiding them at the same time through the exercises not to have them commit serious mistakes in their data gathering, was seen as a highlight for the class. Students were free to search for information in the internet on how to conduct their experiments and they have proven to be not that far off from the methods scientists use in their research. This stimulated creativity and allowed the students to be as active as possible during the learning experience. As some of these students are expected to be teachers in the near future, our hope is that they will teach their pupils using practical methods that both, enhance creativity and stimulates reflection on the issues that connects us with current environmental problems.

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