

# Experiential Teaching for Sustainable Development

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## ABSTRACT

This educational intervention consists in improving the skills of citizenship of students in their first semesters of engineering through participatory management of remote laboratories of air quality in eight different zones of Monterrey, Mexico. With the use of gadgets that can measure the level of pollution in the air, the students were divided into teams of 4 to 5 members and visited their designated area on 3 different days, to measuring the level of pollution in 24 key points within their area: 8 places with a high amount of vehicular traffic, 8 in small streets with little traffic and 8 places in green areas, such as parks. Students scored the measurements and prepared a final report on their area, delivering reports to authorities of local communities. Two focus groups took place, one during the activity and one after the students handed in their final reports. The goal behind the focus group was to listen to the student's thoughts regarding the activity and the knowledge they acquired thanks to it. Interesting suggestions for future implementations were also an important topic during these focus groups. Final reflections and plans for the future run of this activity are discussed in the conclusions.

## CCS CONCEPTS

- Social and professional topics – Sustainability Social and Professional Topics – Student Assessment

## KEYWORDS

Innovation in Education, Experiential education, environment, sustainable development

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## 1. Introduction

According to international agencies, Monterrey is the most polluted city in Mexico with PM 2.5 particles and the third most polluted city in Latin America with PM 10 particles [1]. The consequences of the pollution of this level on public health are serious and makes it necessary to raise citizen social awareness of the students to contribute in a struggle for clean air that is, in the end, a struggle for the benefit of all.

Given the situation of lack of security in many parts of the country in recent years pupils of many universities have restricted their geographic circuits to their academic and social life. The students pass and know less than other areas of their own city other than its neighborhood and university.

From the perspective of urban environmental conflicts in their city, the student is today more emotionally disconnected than before, because it is difficult to feel empathy for affected communities when they are not commonly involved with them. The student has fewer options to build another perception of her/his community other than the superficial dichotomy of more and less privileged areas, which keeps her/his in a distorted relationship with the city, where fellow citizens are not perceived as allies of common interests and agents with great potential for social change, but as a resident of "bad" areas, candidates to deserve charity and aspirants to move to a "better life-style".

As a result, we notice that teachers of the topic "Climate Change" perceive that many students do not feel connected emotionally with this topic. If students were able to develop their citizen competence, the situation would likely improve, making them aware of their role in their communities regarding this topic.

This can be done, more specifically, through the creation of awareness of local problems affecting their city, but especially through active participation to empower the affected communities through collaboration on equitable terms. The empathy and involvement with respect to environmental challenges can be made digital or hard copies of part or all of this work for personal or classroom use is

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improve the feel that the student works to do, and not so much to understand, generating impact on society through methodologies, tools, and cutting-edge technology. be honored. For all other uses, contact the owner/author(s).

In December 2013, Dinamia Strategic Social Research interviewed more than 1400 young people of high school and college students of the AMM in order to investigate what was their perception on air quality in the Monterrey Metropolitan Area, finding that 44% of young people considered that the quality of the air breathed was bad or very bad, 30% considered regular and only a 26%, good.

However, only 14% of the young people interviewed knew where to observe the state of air pollution; 61% thought that industry was the main source of pollution, and 84% believed that the measures taken so far to reduce contamination had not been successful.

Perception surveys have revealed that Mexican citizens consider that the information submitted by the Mexican government on climate change, is biased toward the alarmism, and considers that it serves them to act if the government does not act before, and do not feel responsible for the problem [2]. The need to educate the Mexico's younger generations regarding sustainability has increased in the last five years. Different approaches, such as creating citizen labs, providing platforms that have massive open online courses that teach about this topic, as well as measuring the level of compromise and interest to learn more about the topic have taken place thanks to the network of OpenergyLab, an effort to provide innovative and interesting ways to make participants aware about the need of a sustainable future [3, 4, 5, 6]. And a key element for a sustainable future is the awareness of the level of pollution in the environment, especially in their own communities.

The above reflects an incomplete understanding of the causes and consequences of the problems of atmospheric pollution and climate change, which, according to the model of knowledge deficit, can lead to a reluctance to take action in these problems. In this sense, Branchini et al [7] suggests that the efforts of education in this topic should include project-based learning in action and consideration of individuals within their socio-cultural contexts.

Branchini [7] argues that an effective education required to provide information that users feel as relevant according to their values and perspective of the world. Social networks, for example, favor the formation of online communities with common interests and values, sharing huge amounts of information that is relevant for specific groups. On the other hand, typically those communities directly affected by environmental problems, lack the tools and techniques necessary to participate in relevant decisions to the community, although the development of citizen science activities of collective monitoring type, using low-cost

equipment and easy to use, could empower them in the resolution of this situation.

## 2. Conceptual and Methodological Design of the Intervention

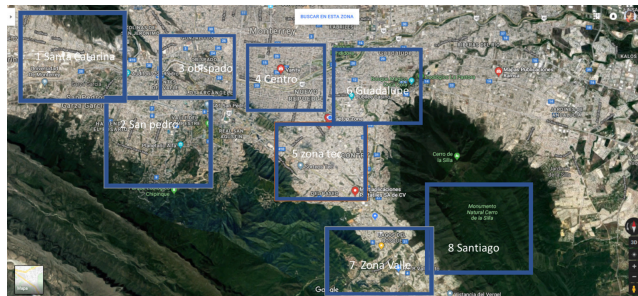
The model of education by competencies is set for years both in the European educational system [8] as well as in the Mexican [9] and the Tecnológico de Monterrey was assumed as its own backbone of their courses [10]. This model incorporates the idea that education emerges from different experiences of life with a systematic approach to knowledge play, interpret and act with expertise in different scenarios [11]. It is a model more holistic and closest to the approaches of environmental education, which from its earliest formulations has been linked to the awareness and resolution of specific environmental issues [12] and questioned the pedagogical approach based solely on the transmission of environmental knowledge, faced with the need to change attitudes and observable behaviors with respect to environmental problems [13]. Against a background of increasing globalization, individualization and cultural uniformity, appears the need on the part of the pupil to manage a greater degree of complexity and uncertainty in environmental issues [14]. To address these issues the student needs to develop not only disciplinary competencies specific to their area of study, but also cross-curricular competencies that enable you to develop a harmonious relationship and participatory with their surroundings [15], and to strengthen the ethical values and emotional intelligence the student to play with mastery, adapting to different contexts [16]. One of these transversal competences is the citizen competence, present in the curriculum of the Tecnológico [17] and defined as the one that trains students to get to know and be sensitive to the social, economic, political and ecological, and to act with solidarity and civic responsibility to improve the quality of life for your community. In the Tecnológico de Monterrey (TEC), the improvement of the citizen competence is more and more participatory and has evolved from the activities of welfarism to community development toward the vision of a more democratic society [17, 18]. Also, the environmental education at the college level has been moving toward the development of key competencies that allow students to participate actively, reflective and cooperative in the achievement of sustainability [14]. Examples of these are the interdisciplinary work, the cosmopolitan perception, cooperation and participatory skills [8]. As a result, the educational activity contributes more to the development of the citizen in the student competition to the extent that this takes a role of greater participation and management. This project will use an active methodology-participatory, frequently referred to as "Citizen Science", and defined as "a methodology of collaborative research that involves equally both researchers and participants and

recognizes the strengths that each brings. Begins with a research topic of interest to the community and helps to combine knowledge and action for social change that improves community health and reduce inequalities in public health" [19]. Citizen science moves away from the positivist paradigm that assumes there is an objective knowledge, separate from the researcher and reachable through an objective process, without prejudice [16]. In contrast, citizen science approaches the paradigm of critical theory for which there is a reality influenced by social, political, economic, cultural and gender that crystallize over time [20]. In this context participant and researcher are connected, and from this relationship emerges a knowledge. Citizen science is characterized by involving the community, and not only to academics, as agent's knowledge producers, to facilitate collaborative relationships with the community at all stages of the investigation and to promote the co-learning and empowerment to reduce social inequalities [16]. It focuses more on process than the results and ownership of these, in which the community assumes full or gradually the definition of the research question, data collection and its interpretation [21] in search of a more action-oriented understanding. This participatory methodology has taken a lot of momentum in the last decade in environmental education thanks to the development of the online software, hardware based on PDA mobile technologies and awareness of the enormous potential that volunteering has as labor, as a source of proposal and talent [22] in training campaigns for the general public ranging from monitoring populations of birds or fungi to monitoring the quality of drinking water or air [7]. Students spend in this methodology to be transmitters of knowledge to be facilitators and collaborators in the creation of new knowledge together with the community, putting into practice actions and attitudes of participation that improve their competence in civic ethics [7, 23, 24]. While developing participatory virtues from environmental education is understood as fundamental to manage the challenges of pollution in the near future [25].

### 3. Description of the Activity

Participating students formed teams of four to five members and chose at random a piece of paper that instructed on what area they had been assigned. Each team received a device designed to measure the level of pollution in the environment: a 2 PM 10 Airbeam and PM 2.5. The teams were organized, and they visited their allocated area on 3 different days, by measuring the level of pollution in 24 key points in their area: 8 places with a high amount of vehicular traffic, 8 in small streets with little traffic and 8 places in green areas, such as parks.

Students scored the measurements and prepared a final report on their area, delivering reports to authorities of local communities in their assigned area.



**Figure 1. Map of the different areas that were assigned to the students for the activity**

Follow-up on the educational intervention was reflected in the assessment of students in the field that were studying. Activities were carried out before, during, and after the students went out to make measurements in their assigned areas. Students developed a single drafting in which you asked to formulate the problem of urban pollution of their city, its actors, factors and state of the problem.

After having the experience of going to make the measurements for three days, students gave a document with a list of the records of data of pollution that collected and information for contacts with the community to which he handed over its final report. At the end of the project a final report was delivered. In it each group reported the pollution levels and shared personal reflections and learnings about the project.

### 4. Evaluation of the Activity

In order to comprehend the impact and the opinion of the students regarding this activity, two instruments were applied before and after the activity took place. The first instrument was a test designed Shepherd et al (2008), called the Sustainable Development Scale, which analyzed the level of reflection of the student in relation to sustainability.

Students performed the test at the beginning of project and at the end of the project. Secondly, the authors conducted a focus group with 12 students with the intention to listen to students who carried out the activity, which involves measuring the level of pollution around different areas of the city in which they live.

During the focus group, data were collected on the student's first impression of the activity when they were presented with the instructions for the first time, their experiences while working on this project, the difficulties that they could have faced to calibrate or read the data, the way in which they decided where and how they should use

the measuring device according to its criteria, the interpretation of the results they had collected so far and if the activity had reached their expectations. They were also asked to share any information deemed necessary that could be useful for future runs of this activity in future generations. Other key points that were treated in the focus group included:

1. If the instructions were clear enough
2. If the activity had a high level of difficulty to complete
3. If the device to measure the level of pollution was easy and intuitive to use
4. If this activity had an impact on the way in which they perceive themselves and their environment
5. If the activity had served to raise their level of awareness about the level of pollution in their environment
6. If this practical experience could really change the perspective of future generations, according to their opinion
7. If the intervention qualified as something useful, innovative, fun or any other adjective considered reasonable.

## 5. Participants Input from the Focus Groups

There were two focus groups that took place. The first one happened when the students were still measuring the level of pollution in the areas they were assigned. When questioned about the activity and their experiences in the field, the participants expressed pride in the fact that they had been assigned a role that would have a lasting impact, going beyond just being “one more grade” in their formation. Part of the activity involved the students writing a report that they would have to hand in to an authority pertaining to the area they were assigned.

More than half the students mentioned that the research and the time they invested to contact the authority they would hand the report was something a bit out of their comfort zone, but also helped make them more aware about the entities that exist in the area they were assigned. There was a team of students in particular who expressed that they had never visited the area they were assigned before. Having not only to visit the area but do research about it beforehand in order to pinpoint the areas they would assign in order to go measure for the three days taught them about planification and organizing team efforts in order to comply with the instructions they were provided.

All the students that participated in the first focus group mentioned

that the device they were handed to make the measurements of pollution was very intuitive and easy to use. One of them even expressed “there is literally just one button in it. There is no way you could not figure out how it works”. However, during

the first focus group, students were still unsure about what the numbers meant. They still lacked an understanding about what exactly they were measuring and what it meant.

In the second focus group, students had already handed in their final reports and had their grades assigned. Thus, they felt more comfortable sharing how they felt about the activity after they were assured that their teacher wouldn’t know who said what and that their grade wouldn’t change depending on what they said. All the feedback provided was protected under anonymity, and thus, the students agreed that even though it was a very tiring and time demanding activity, the experiences and stories that arose from them meant that they would never forget what they learned during their class.

One participant in particular voiced how their hypothesis regarding the level of pollution in their assigned area was completely different to what they thought it would be. The team had thought that the level of pollution would be higher out in the streets, compared to a park. However, they soon learned that the level of pollution in the park was higher, mainly because air helps move pollution from one spot to another and that means that all the pollution created by cars ended up moving to areas they didn’t expect. “That was really eye opening to me” the student mentioned. “One assumes they know how things work, but it isn’t until you are out in the field, measuring the things with your own two hands and seeing the results with your own two eyes that you realize... wow... I still have a lot to learn. And that was challenging. And fun”.

Not all the feedback was positive though. Some students expressed the lack of planning beforehand to have been a negative aspect of the activity. For example, when the teacher told them to form teams, they just went with who they knew or were already friends with. However, when they had to go do the measurements in the different areas they were assigned, they suddenly realized that none of the team members owned a car. Meanwhile, in other teams, all the members had cars.

“They should tell us beforehand to consider all of these things before making the teams” one student mentioned, and all the other students in the focus group agreed. Thus, planning for a survey to be run before forming the teams, in order to help students plan their schedule and teams with some a guidance about what is expected of them directly will be applied in future runs of this activity. In general, students showed gratitude for the experience, and expressed that their level of awareness regarding pollution and the need for a sustainable future showed a positive change. Some of them even began to car pool together in order to help out the environment in their own areas. Their attitudes and perspective regarding pollution was greatly influenced by this activity. They also believe that, once the small administrative problems that arose during this first run are addressed, future generations might enjoy the activity and feel satisfied with the feeling of having their school work have an impact in the “real life world” by providing a report

to authorities that might take measures and address the topic of pollution in the environment. "You finish the activity and feel satisfied, because you learned something new and, in the process, you are helping your community" said one student as a final conclusion to the second focus group that took place.

## 6. Conclusions

Allowing the students to organize themselves and work in teams in order to provide a final report that was going to be read by an authority in the area they were assigned really had an important impact in the level of motivation of the students. When they were questioned about the impact that the activity had in their learning process, many of them commented that they had had to explain to their friends and family what they were working on and that they felt satisfied to see that what they were doing was considered "important" since it would have an impact beyond the classroom.

Also allowing students to explore new areas maybe they had never visited before opened the door for them to put in practice their researching skills and their teamwork planning. Some teams had a hard time because they lacked a vehicle to transport themselves to do the measurements, so the feedback received from the students in order to prepare better environments and planning of the sessions in which they had to go out to measure the level of pollution are in the work for future runs of this activity.

In general, the experience of going outside and measuring with their own eyes the level of pollution of the places they were assigned helped the students reflect on the environment and the impact that their daily attitudes and actions have. Most of the students thought that the activity was worth being run again for future generations, since they believe that the impact that it had in their learning process really was worth the effort, regardless of the difficulties they faced. Since the product of this run gave the authors a lot of interesting opinions and feedback from the participants, we want to share through this proposal that experiential teaching can have a positive impact in the lives of the students and their communities in order to raise awareness about the need for a sustainable future.

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