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SENSING LOCALLY IN THE GLOBAL ENVIRONMENT: USING SENSORS IN TEACHERS' EDUCATION

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ABSTRACT

In order to develop elementary school children's environmental citizenship, the 21st century teachers have to improve their own environmental literacy, and electronic sensors can have an important role in that improvement. The research presented in this paper describes an environmental education project that uses electronic sensors to support future teachers in thinking globally, while sensing and acting in their local environment. Future teachers used sound sensors, temperature sensors, as well as carbon dioxide sensors, together with smartphones, to explore natural and urban systems in order not only to characterize these systems, but also to: i) understand ecosystems' services and interconnectedness; ii) identify environmental problems; and plan related solutions in what concerns climatic comfort and air quality. The data acquired and produced in ecosystems' explorations were selected and are presented in this paper, as well as the related interpretations. The learning results are related to: i) the local characterization of a natural ecosystem and of the teachers' education school campus; ii) the differences and relations between Lisbon urban systems and the neighboring natural ecosystems; iii) the identification of interventions to improve environmental quality of the campus. This research contributed to validate the use of electronic sensors and smartphones as a useful strategy to produce environmental information about the explored ecosystems, to link local and global approaches in environmental education, as well as to support students' actions, planned to enhance the Campus environment.

KEYWORDS

Sensors, Environmental Education, Teachers' Education

1. INTRODUCTION

In the context of the development of fundamental competences for the 21st century and of elementary school children's environmental citizenship, this research emphasizes environmental citizenship and the use of ubiquitous digital tools, such as electronic sensors, aiming at supporting future teachers in sensing locally natural and urban ecosystems, to understand local and global ecosystems.

New technologies together with transnational environmental problems are fundamental drivers of the definition of the skills and knowledge needed to the 21st century (Scott, 2015). Furthermore, UNESCO (2017) stresses that the quality of education, including the content of the education provided, and the excellence of teachers, is crucial for achieving sustainable development, and all of the Millennium Development Goals (MDG). In this context, the integration of sustainability into education will support natural literacy and a consequent desire to protect and restore nature (World Business Council for Sustainable Development, 2010).

The research presented in this paper is grounded on the idea that twenty-first century students must develop the ability to make sense out of significant and complex global issues, through an education centered on real world issues, and on problem, inquiry and project-based learning strategies, enhanced with new technologies (Scott, 2015). Accordingly, the research presented in this paper is part of the Glocal Act project (Knowing the global environment to act locally: From learning in natural spaces to urban intervention). Glocal Act is an education for conservation project, which aims to develop: i) future teachers learning in natural surroundings of Lisbon; ii) future teachers understanding of the ecosystems services and of the relations of these spaces with the city; iii) a consequent environmental intervention located in an academic Campus in this city.

In a subsequent stage, the Glocal Act project will support participant future teachers in adapting and implementing similar environmental activities with children, also aiming at environmental exploration and critical reflection to improve local environments.

Following this introduction, the previous and related work will be presented, as well as the methodology, the late breaking results, and the conclusions. The last section includes the bibliographic references.

2. SENSING LOCALLY WITH ELECTRONIC SENSORS

In this paper, the authors present the late breaking results of the Glocal Act project, specifically the acquisition and interpretation, by students of a Teachers Education School, of environmental information of two ecological systems: a Lagoon near Lisbon and the outdoor space of the Lisbon Polytechnic Institute Campus. Electronic sensors are used in this research to support students of a teachers' education school in thinking globally, while sensing and acting in local environments.

2.1 Previous and Related Work

The Globe project is a pioneering participatory project that started in 1995. In this Project, the data collected with sensors by schools are processed and presented for local and global interpretations (Globe Program, 2017). Since the beginning of the 21st century, tools such as mobile devices (e.g. PDA and smartphones) and sensors (e.g. GPS, cameras, and sound and temperature sensors) have been used in participatory environmental activities. Ambient Wood (Rogers *et al.*, 2005), MobGeoSens in Schools (Kanjo *et al.*, 2008) are examples of projects that built and used mobile devices to monitor real-world environmental parameters, in georeferenced environmental sense making activities.

Environmental sensor kits have been multiplied, (McGrath, and Scanaill, 2014) with the increase of the daily use of smartphones with Internet access (Ferreira, Ponte, Silva and Azevedo, 2015) and the development of widely accessible sensors. As a result of the persistent use of digital and mobile technologies, most students today are natural researchers, since those technologies are an effective way to support independent and enquiry-based learning (Scott, 2015). This use of mobile technologies also allow for instant and reflective assessment (Scott, 2015). The two following projects are examples of such affordances. The Kids Making Sense program (Kids Making Sense, 2017) empowers youth to collect credible air quality data around their neighborhoods. Students can even use their data to identify local sources of air pollution and take actions to be part of the solution. This program was developed by air quality scientists and educators. In the USense2Learn project, children used environmental sensors and smartphones to create georeferenced multisensory information. Children assessed the environmental quality of their schoolyards and shared the developed knowledge into the classroom, and to other classrooms, using Google Earth (Silva, Lopes, Silva and Marcelino, 2010).

In this research, students of a teachers' education school used mobile sensors together with mobile phones and Google Maps to sense a natural system of the neighborhoods, and the outdoor environment of their Campus, to reflect critically and globally on the acquired data, aiming to improve the Campus environmental quality.

2.2 Methodology

This research is being developed in the context of initial teachers' education in a Higher Education School in Lisbon, Portugal. It uses a qualitative methodology, centered on a case-study approach, in which the teacher was also a researcher, making it possible participant observation. The case-study activities are organized in three phases:

1. Use, by a class of 15 students (14 female and 1 male), of the carbon dioxide sensor and of the temperature sensor, together with smartphones/tablets, to acquire environmental data, while exploring a Lagoon natural system, close to Lisbon (31km) – February 2017;

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2. Use, by a class of 16 students (2 male, 14 female), of the sound, carbon dioxide and temperature sensors, and of the digital microscope to explore the outdoor environment of their academic Campus. The results of the explorations were mapped by the students in a collaborative map of Google Maps – September 2017;
3. Critical interpretation of the environmental information acquired in the two systems, by two classes (one of 16 students, 2 male, 14 female, and another one with 23 students, 21 female, 2 male), and planning of interventions in the Campus– September 2017.

Future teachers worked in groups of four to five students, and used a PASPORT Weather Anemometer Sensor (PS-2174), a PASPORT Carbon Dioxide Gas Sensor (PS-2110), as well as a portable USB Digital Microscope.

2.3 Late Breaking Results

The data, acquired by students with the sensors in the Lagoon natural system, were presented in graphics (figure 1), while the sensorial and quantitative data acquired in the Campus system were georeferenced and presented, using images, numbers and text (figure 2 and table 1). In figure 1, the graphics show that the temperature and CO2 values are changing in time, since the groups with the sensors were moving, and carbon dioxide values are low most of the time, with peaks when the group went into the birds' observatories. In the two placemarks opened in Figure 2, the groups of students registered the sound level (mean 69,43dBC, maximum 74,44dBC) and the carbon dioxide data (mean 586ppm, maximum 1164ppm), acquired near the main road. This road was identified as a source of noise and air pollution, since those values far exceed 400 ppm, the mean value of CO_2 in atmosphere (WMO, 2016), as well as the limit of 60dBC for the ancillary learning space (Lilly and Wowk, 2010). These values also exceeds the ones further from the road. The canteen is an interior noisy place.

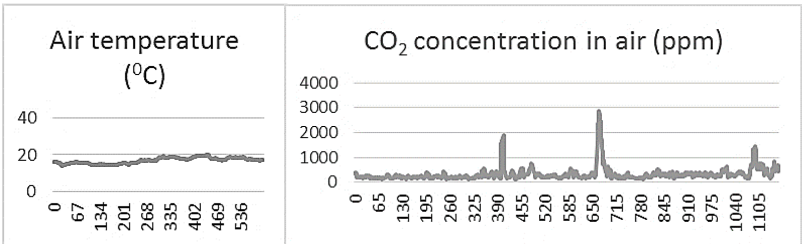

Figure 1. Data of Air Temperature and Carbon Dioxide in Air Vs Time (S), Acquired in the Lagoon Natural System

Figure 2. Collaborative Map of the Outdoor Environment of the Camp, with the Several Placemarks Created by Students. Two of the Placemarks, Near the Main Road Are Showing Their Content

Table 1. Selected Data Acquired by Students and Mapped Using Placemarks

Placemark	Carbon dioxide (ppm)		Placemark	Sound level (dBC)	
	Mean	Maximum		Mean	Maximum
1	371	425	**4**	69,43	74,44
2	336	493	**5**	50,10	70,97
3	586	1164	**6** (canteen)	68,37	97,16

Based on the acquired data, students were able to: i) use the sensors without difficulties, in a engaged way; ii) recognize the low levels of CO_2 (below the planetary mean) of the Lagoon system, while relating these low levels to the photosynthesis and the CO_2 peaks to the lack of quality of the air in the human crowded observatories of birds; iii) identify environmental problems of the Campus, such as thermal discomfort, sound pollution, and CO_2 pollution, while recognizing their causes; iv) envision a set of solutions to the identified problems, namely to plant trees to create shadow (they used the sensors to prove the lower temperatures at the shadowed places), and to place a barrier, “for instance of cork”, to protect the Campus from the traffic noise.

Teacher mediation was needed to: i) inform the global average concentration of CO_2 in Earth's atmosphere, to allow comparisons and deduce explanations; ii) provide information on the consequences of sound levels to human beings, also to allow comparisons and deduce explanations; iii) call attention to the similar thermal amplitude verified when comparing temperatures at shadow or at direct sunlight both in the Lagoon system and in the Campus; iv) support students’ reflections on the potential of the Lagoon system to improve Lisbon’s environmental quality, specifically in what concerns air pollution; v) inform about the possible use of vegetation, bushes and trees, as acoustic barriers; vi) supply information about the indigenous species, and the invasive species, to facilitate the creation of more complete solutions by students.

3. FINAL REMARKS

The late breaking results of this work contributed to the validation of the use by future teachers of electronic sensors, together with smartphones, as a useful strategy to produce environmental information about a natural and an urban ecosystem, and to critically reflect on it. Teacher mediation was important to support students in using such information in linking local and global approaches to environmental problems, and in planning actions to enhance the Campus environment. Future activities will include a more extended (in space and time) characterization of the Campus and of other natural systems near Lisbon, by future teachers and schoolchildren, to improve local sensing, global thinking and local interventions.

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