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Sensing the Environment with Human Senses and Electronic Sensors in Teachers Education

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INTRODUCTION:

Senses are the fundamental interface between human beings and the environment and they are part of everyday experiences (Mason, & Davies, 2009). Sensors can be considered extensions of human senses (Magnani, 2004). In the SOS Abstract research project (Using Sensors and Senses in the Environment to Develop Abstract Thinking), sensors are approached as learning mediators (Magnani, 2004), since they can be used by students to explore natural phenomena in a more motivated and engaged way, extending their thinking and creating multiple representations of their understanding (Hug, Krajcik and Marx, 2005). In environmental education, children can use senses and sensors to observe, represent, and control variables in authentic activities that explore complex concepts while developing children's abstract thinking (Silva et al., 2013).

In order to improve environmental health education through the joint use of human senses and electronic sensors, it is necessary to empower future teachers with a set of experimental and didactic competences during pre-service and in-service training.

OBJECTIVES:

In the work here presented, in order to support future elementary school teachers in developing environmental authentic activities, using human senses and electronic sensors, the authors developed a set of resources and validated them through their use in the School of Education of the Polytechnic Institute (a teachers' training school). Two kinds of resources were developed and used:

- Empirical resources: experimental protocols and environmental data resulting from the characterization of a set of variables of indoor air quality and of Douro estuary water quality;
- Theoretical resources: background information on the relevance of the characterized variables to environmental health education.

MATERIALS AND METHODS:

The empirical and theoretical resources were produced in the framework of the SOS Abstract research project, in the context of two environmental health undergraduate traineeships and one undergraduate research project, which also contributed to a PhD project that studies the use of senses and sensors in authentic activities with children.

In the environment of the School of Education of the Polytechnic Institute, a set of variables related to environmental health, namely indoor air quality variables - such as temperature, humidity, illuminance, sound level, and carbon dioxide concentration - and Douro estuary water quality variables - such as conductivity, turbidity and pH - were studied, using senses and sensors (Table1). It was on the basis of this environmental qualitative and quantitative characterization that the empirical and theoretical resources were created and used to support authentic learning activities.

Table 1 - Variables, electronic sensors and human senses used to characterize a set of variables of the School environment

Variables	Electronic Sensors	Human Senses
Temperature	Pasco PS - 2124	Somatic senses ¹
Humidity (absolute and relative)	Pasco PS - 2124	Somatic senses
Sound level	Xplorer GLX para modo sonómetro, Pasco PS - 2002	Auditory sense
Carbon Dioxide Concentration	Pasco PS - 2110	Somatic senses
Illuminance	Pasco PS-2106A	Visual sense
Conductivity	Pasco PS - 2116	Somatic senses, Gustatory (taste) sense
pH	Pasco PS - 2147	Gustatory (taste) sense
Turbidity	Pasco PS - 2122	Visual sense



Figure 1 - Photographs of three sensors used to characterize the School's indoor environment: Humidity and temperature sensor (Pasco PS - 2124); light sensor (Pasco PS - 2106A) and carbon dioxide sensor (Pasco PS - 2110)

RESULTS AND DISCUSSION:

The implemented environmental characterization allowed reporting that:

- The School's indoor environment is heterogeneous regarding the evaluated variables. Some measured values exceeded the reference values, namely in what concerns temperature, and sound level. Suggestions were made to solve the detected problems;
- The analyses of Douro estuary water, performed in four locations, illustrated the complexity of the estuary environment and of the variability of salinity and turbidity;
- In some cases, the sensory evaluation made by the trainees produced estimations that were not in accordance with the values that were subsequently measured by the sensors. Such discordance motivated relevant reflections and informed posterior estimations;
- It was clear that the used sensors were adequate to didactic activities (given their robustness, easy, rapid and regular functioning, as well as their efficient way of making data visible and comparable) and that they were inadequate for analysis of environmental compliance. They allowed the analyses of the variations of the measured values in different locations, but the comparisons with the reference values were not always reliable. This was the case with the light sensor. Therefore, it was necessary to use of a more rigorous luxmeter (MAVOLUX 5032C/B USB) to make comparisons with the reference values.
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This environmental characterization informed the creation of the empirical and theoretical didactic resources. It is important to highlight that:

- The experimental protocols integrate not only procedural instructions but also background information on each variable and on its environmental behavior and relevance to environmental health education;
- For each environmental variable, a didactic activity was designed and implemented, guiding and supporting future teachers in qualitative multisensory explorations and estimations and in

¹ Somatic senses allow the sensation of pressure, vibration, pain, temperature, as well as noxious sensations.

subsequent comparisons with the quantitative results of the use of sensors. These activities are being implemented in a successful way, engaging future elementary school teachers;

- In those activities, future teachers are challenged: to use their senses in a free, exploratory and meaningful way to characterize the environment and to make a better use of sensors; to discover the qualitative and quantitative variations of each variable in their everyday spaces, as well as the influencing factors and the consequences to the quality of life; to understand the complementarities of senses and sensors.

CONCLUSION:

In this work, a set of empirical and theoretical resources were developed to guide and support future teachers in using human senses and electronic sensors to explore and characterize their everyday spaces, developing awareness and competences related to environmental health education. The interdisciplinary nature of the authors' team facilitated the emergence of meaningful links between environmental health and teachers education.

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