Beyond technology, through research in education:

The collaborative situated design of an environmental health education platform

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***Abstract*— The research presented in this paper is centered on the design process of a participatory environmental health education platform. The platform was collaboratively designed by a team of environmental education, environmental health and information and communication technologies (ICT) experts, based on the results of previous projects on ICT in education, on science education knowledge, and on a set of research experiments in educational contexts. The design process was situated in the context of Portuguese primary schools' spaces, and of its environmental health problems, as well as in primary schools' science education curricular activities. The designed platform will support monitoring and action in health, and environment, and will include a searchable, and updateable database integrating the annotated environmental health data, created by school children, schools' blogs, and schools' collaborative documents.**

Keywords—environmental health; education; platform; design; situated

I. INTRODUCTION

The Eco-Sensors4Health project (Eco-sensors for health: Supporting children to create eco-healthy schools) aims at improving environmental health in schools, through the assessment and intervention on environmental factors that may affect health. The research described in this paper aims, as part of the Eco-Sensors4Health project, to develop a collaborative platform for monitoring and intervention in environmental health, enabling children's eco-innovation in the creation of healthy and sustainable environments in schools, using everyday Information and Communication Technologies (ICT), like mobile phones, tablets, and the eco-sensors. The collaborative platform will be participatory and targeted to primary schools' communities of practice, with a special focus on children not only as explorers, but also as decision makers in environmental health.

The relevance of the Eco-Sensors4Health project is its potential to improve environmental health, mobilizing ICT (a collaborative platform and mobile devices) and empowering school children. It uses ICT as essential everyday components, according to European and Portuguese Digital Agendas [1], to improve schools' environmental health dimensions, such as noise, air quality, climatic comfort. In this project, the originality is related to the creation of tools that empower children and school communities in using ICT to monitor the environment, to better understand the interactions between school everyday conditions and schools' environments, and to eco-innovate in decision-making to improve school environmental health.

The design process of the participatory platform will be described in this paper. The theoretical framework and the previous and related work, on which the platform design process is based, are presented in the next section. Sequentially, the platform main features are specified and justified. Afterwards, a set of resources, designed on the basis of previous projects and of research experiments, developed in educational contexts, are described, to be integrated in the platform. Finally, the specifications of the platform are clarified. The conclusion and bibliographic references close the paper.

II. THEORETICAL BACKGROUND AND RELATED WORK

A. *Theoretical background*

The Eco-Sensors4Health project is a design-based research centered on the collaborative situated design of an environmental health education platform. This project adopts an approach to educational technology research grounded in the ends of technology, recognizing technology as a process and focusing into how, when, and why innovations work in practice. Technology is much more than hardware and software, it is a process that involves the complex interactions of human, social, and cultural factors as well as the technical aspects. Using technologies in education is not just about devices and apps it is about improving and refining the process of teaching and learning and, consequently, the design of learning environments.

Design-based research is not about specific designs and curricula, but on how the strengths and limits of a design

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inform theories of learning, addressing the complexities inherent in educational technology research [2]. Design-based research is a suitable approach to investigate and develop educational technology because it is about "... addressing complex problems in real contexts in collaboration with practitioners; integrating known and hypothetical design principles with technological advances to render plausible solutions to these complex problems; and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles" [3] (p. 58).

The process of knowing in educational technology research is not disconnected from practice, and therefore implies change. Design-based research aims to build a stronger connection between educational research and real-world problems. There is a cycle of research based on an iterative research process that goes beyond evaluating innovative products or interventions, systematically attempting to refine the innovation and to produce design principles that can guide similar research [3]. A design-based research in educational technology starts with researchers and practitioners collaboratively analyzing practical problems of their educational context, which leads to the development of solutions informed by existing design principles and technological innovations, and to iterative cycles of testing and refinement of solutions in practice, supporting reflection to produce 'design principles' and enhance solution implementation, feeding-back the refinement of problems, solutions, methods and design principles [2].

According to the Design-Based Research Collective [4] a design-based research accounts for how designs function in authentic settings, not only documenting success or failure, but also focusing on interactions that refine our understanding of the learning issues involved, leading to theories that communicate relevant implications to practitioners and other designers.

The design process of the Eco-Sensors4Health collaborative platform incorporates the five characteristics of design-based research identified by Van den Akker et al. [5]: interventionist, iterative, process oriented, utility oriented, and theory oriented. Researchers of Eco-Sensors4Health project are committed to conduct interventionist research in schools, accepting the complexity of the setting. Schools are "living laboratories" [6] in which researchers investigate in real world settings while attempting to control for critical variables identified through theory and previous research [7] [8]. The Eco-Sensors4Health project is organized as an iterative process in which research and practice are intertwined, and teachers and students are active partners in identifying priorities for research and contributors throughout the research process itself.

The Eco-Sensors4Health project by adopting a design-based research aims not only to solve the practice-oriented problems addressed by action research, improving environmental health in schools, but also to identify reusable design principles of the collaborative platform.

B. Previous and related work

The design process of the Eco-Sensors4Health collaborative platform is informed by previous studies and projects on how to support children in using sensors to portray the environment of their schools, and in publishing and sharing such information: i) in the SchoolSenses@Internet project, primary schoolchildren created multisensory georeferenced information, using human senses and GPS equipped mobile phones, while learning about new dimensions of their schoolyard environment, creating multiple views of environmental quality and having a voice in the environmental assessment of their schoolyards [7]; ii) the USense2Learn project added environmental sensors to the mobile creation of georeferenced multisensory information, making it possible to bring quantitative and qualitative visions of the outside world into the classroom and to share it with other classrooms, using Google Earth [8]. These two projects used GPS equipped mobile phones networked through a specific platform to allow children to sense the school environment.

Besides those two previous projects, there are numerous participatory science projects based on the development or innovative use of data-driven, technology-powered tools that create learning experiences for citizen scientists, including students. In these projects participants can design and/or implement tools that support citizen science work, particularly data collection or data analysis. There are some of these projects that are related to the Eco-Sensors4Health project.

GLOBE - Global Learning and Observations to Benefit the Environment [9] is a science and education program that connects a network of students, teachers, and scientists from around the world to better understand, sustain, and improve Earth's environment at local, regional, and global scales. GLOBE started in 1995, and to date 120 countries have participated, and more than 150 million measurements have been contributed to the database, creating meaningful, standardized, global research-quality data sets that can be used in support of student and professional scientific research. GLOBE protocols have been developed for the following Earth system science study areas: Atmosphere, Biosphere, Hydrosphere, and Soil (Pedosphere). Measurements include weather, climate, air quality, water quality, soils, vegetation, and timing of plant and animal responses to seasonal environmental changes. GLOBE has created over 100 protocols and learning activities relating to the four Earth system science study areas, supporting the work of teachers, students and scientists.

Participatory Science Platform (PSP) [10] aims to support scientific research in New Zealand where community groups and science professionals work together in a meaningful way on locally-relevant scientific research projects. PSP goes beyond scientists' crowd-sourcing their data, it builds a true partnership between scientists and the broader community. PSP aims to engage students, schools, collectives and community-based organizations with science professionals to carry out collaborative research projects that have scientific value, pedagogical rigor and resonate with the community.

Vigie-Nature is a participatory science program supporting biodiversity [11] launched in 2010 in France. At this stage,

there are seven protocols available which allow the study of various types of subjects (birds, snails, wild plants, pollinating insects, brown algae, earthworms, bats). By following the protocols students collect data of their observations and send it to researchers at the French Museum of Natural History via the Vigie-Nature School website. The scientists then analyses this collection of data to evaluate the state of biodiversity in France and the impact of humans on biodiversity. The protocols offered allow students to act, to think and to conceptualize, and therefore better understand the world around them. By participating in these protocols, the students become familiar with the biodiversity around them and start to refine their sense of observation. To actively participate on nature observation and data collection fosters students understanding of the mechanisms and construction of scientific knowledge. The connection with researchers is a strong form of motivation as the students feel they are part of the research and are given responsibility in the project.

The iSpot project [12] aims to create a service which enables people to learn more about natural history by helping them to identify observations of nature. People can upload their observations of wildlife, help each other identify it, and share and discuss what they've seen. The iSpot project in UK and Ireland started in 2008 and has over 18,000 registered users and over 100,000 observations. An iSpot user can post observations of animals and plants on the site and the iSpot community will help to identify them reliably. Users can use geo-tagged images (images with GPS data included in them about their location) or add information about where an observation was discovered. The service has an 'expert panel', a mixture of amateur and professional naturalists who volunteer their help, which ensure that observations are identified quickly and accurately. The site uses Google mapping technology to allow people to search and filter using various tags and identifiers to see where observations were discovered. The project team at the Open University has developed the iSpot community which now includes more than 80 natural history organizations. A sister iSpot site has been created for Southern Africa, whose content and experts are managed by staff at the South African National Biodiversity Institute.

The presented projects have some common features that can inform the design process of the Eco-Sensors4Health platform, specifically all the projects promote educational scientific inquiries, making available a platform that allows data collection and data searches of situated environmental information.

III. Definiton of Platform Main Features

The design process of the Eco-Sensors4Health platform was developed by a team of environmental education, environmental health and information and communication technologies (ICT) experts, based on previous projects, on ICT in education knowledge, and on a set of research experiments in educational contexts.

The design process considered the complexity of the environmental problems (multiple variables and multiple relations between variables) and of the primary school community of practices (challenges of environmental health learning by children from 6 to 10 years old).

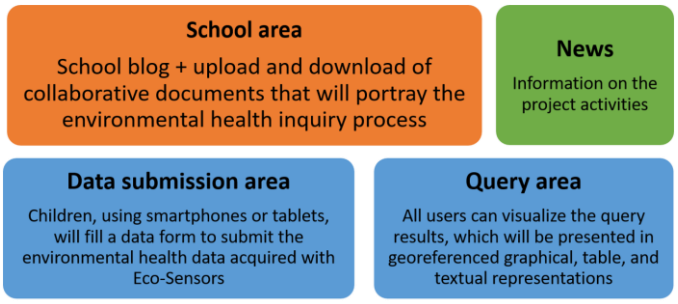

Fig.1 – Main areas defined for the Eco-Sensors4Health platform

The Eco-Sensors4Health platform should support the primary schools communities of practice, and blogs can have an important role in that. Blogs are a key part of collaborative online technologies, merging interaction and publication, the individual and the community [13]. Furthermore, blogs are adequate to be used in schools, and can create a learning environment, facilitating critical thinking, collaboration, and differentiated instruction, using multiple learning styles. Therefore, in the design process of Eco-Sensors4Health platform, it was decided to have a blog for each participant school area.

In addition to the school blog, each participant school area will integrate an area to upload and download of collaborative documents that will portray the environmental health inquiry process.

Previous related projects, referred in the previous section, such as the Globe Program and the SchoolSenses@Internet project, informed the definition of two central areas of the Platform: i) a data submission area, where children, using smartphones or tablets, will fill a data form to submit the environmental health data acquired with Eco-Sensors; ii) a query area, where all the users can fill a query form and visualize the query results, which will be presented in georeferenced graphical, table, and textual representations. These two areas are fundamental in participatory platforms of diverse educational projects on environmental exploration [7] [9].

The data forms and the collaborative documents were designed on the basis of research experiments in educational contexts, which will be described in the next section.

IV. Platform Resources

The Portuguese National Plan for School Health (PNPSH) highlights indoor air quality, climatic comfort and noise as examples of the main schools' environmental risks [14]. Based on this Plan and on related studies on these risks in primary schools [15] [16] [17], the Eco-Sensors4Health project selected four environmental health variables to be studied by children in the participant primary schools: sound level; concentration of carbon dioxide in the air; air temperature; and humidity. The situated exploration of these environmental health information is part of the primary school curriculum in Portugal.

To design the data forms that will be used by children and teachers to introduce the data acquired with eco-sensors in the platform, a set of experiments were developed in the Ciência Viva School (CVS), a museum-primary school project in Portugal, which promotes a weekly schedule of activities with Lisbon school classes of the 3rd and 4th grades. The two teachers in charge of the Eco-Sensors4Health activities in the CVS are researchers in the project.

In order to monitor environmental health conditions and to identify related problems:

- More than 900 children used tablets to measure sound level in the classroom and in the garden. Children were able to use the SparkVUE app to acquire the maximum, minimum and average values of sound level in different environments, while performing different activities, such as making silence, clapping hands and singing. Furthermore, they were able to register the acquired data in register forms that were iteratively developed and that currently include the following fields: name, school, date, a table to register sound level in different activities, and a field to introduce text related to each measured sound level. All this data was interpreted by children with teacher mediation [18].

- More than 100 children engaged in a set of activities that use a carbon dioxide sensor to measure the concentration of this gas in the classroom, during the class with the door closed, and afterwards with the door open; in the garden; near the road; and in a bottle with exhaled air. Children were able to read the data acquired with the sensor, and to register such data in a register form that include the following fields: name, school, date, a table to register the concentration of carbon dioxide in the different environments. The data was interpreted by children that were able to relate the variations with the presence and proximity of carbon dioxide sources and sinks.

Those learning experiments implemented in an educational context, made it possible to validate the fields of the data forms to introduce data in the Eco-Sensors4Health platform. This way, it was decided to include the following fields: school; experiment; date; hour; location; intervention/activity; value and text for each variable.

The design of the collaborative documents that will portray the environmental health inquiry process, and that will be uploaded and downloaded in each school area, was based on experiment plans, used, and validated, in previous studies [19] [2[19]]. Collaborative documents will include an experiment plan with the following fields: thematic of the inquiry; what we can change (independent variable); what we will measure (dependent variable); what we will control; what is the question; what we will need; how we will do; what we expect to happen; validated register forms (data tables; graphs; photos; audio; video; pictures; text); answers to the question and conclusion. Experiment plans and observation tables and charts were validated as important learning tools in similar contexts (scientific inquiries with eco-sensors in elementary schools), not only because they separate observations from interpretation and estimative, but also because they make scientific strategies explicit and visible [19]. Besides the experiment plan of the inquiry, collaborative documents will also include the following questions to be answered by children with teacher mediation: "What environmental health problem can we identify?"; "How can we improve the situation?"; "What are the results after the improvements?".

V. Platform Specifications

The users of the Eco-Sensors4Health platform are elementary school children, elementary school teachers, administrators, and public in general. The general public can use the web portal to access project news and information about participant schools, and also to perform georeferenced and quantitative queries on the environmental health data created by children with the eco-sensors and also uploaded by them to the platform.

Children and teachers can access their school area in the platform, using login and password. In this area, they can use and edit their school blog. Teachers are responsible for managing the collaborative documents that document the inquiry processes of each school experiment. In each participant school area, children and teachers can use smartphones, tablets or laptops to upload the environmental health data acquired with eco-sensors. The upload to the data base is made using a data form (presented in the section IV of this paper). Administrators are the ones who validate the data uploaded by children and teachers. Fig. 2 summarizes the different components and the main data flows of the Eco-Sensors4Health platform.

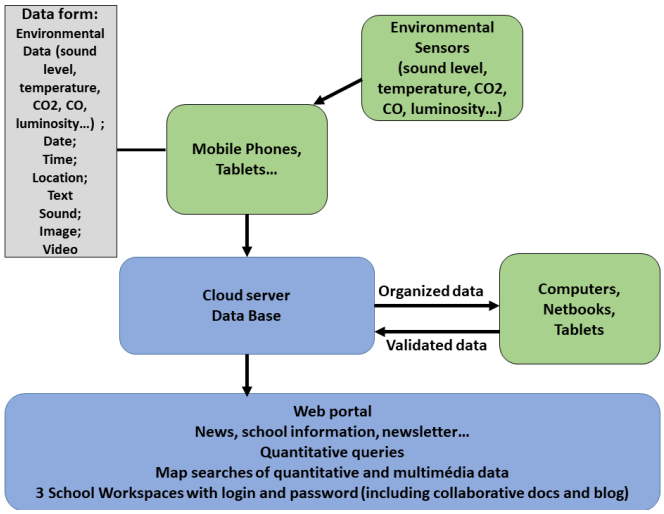

Fig. 2 – Data and components in Eco-Sensors4Health platform

In this context data model is centered on two key entities, the Experiment and the Measure. Experiment entity comprises group characterization, students and teacher, and a description about the experience. It records which variable is being measured, more specifically which sensor is being used. Measure entity refers to data acquired in real context. In addition to the sensor reading, it integrates attributes such has date, hour and place of data collection, as well as sensor measure conditions, with or without intervention. Complementary data about the measure can be added in a diversity of formats. Fig. 3 represents database model.

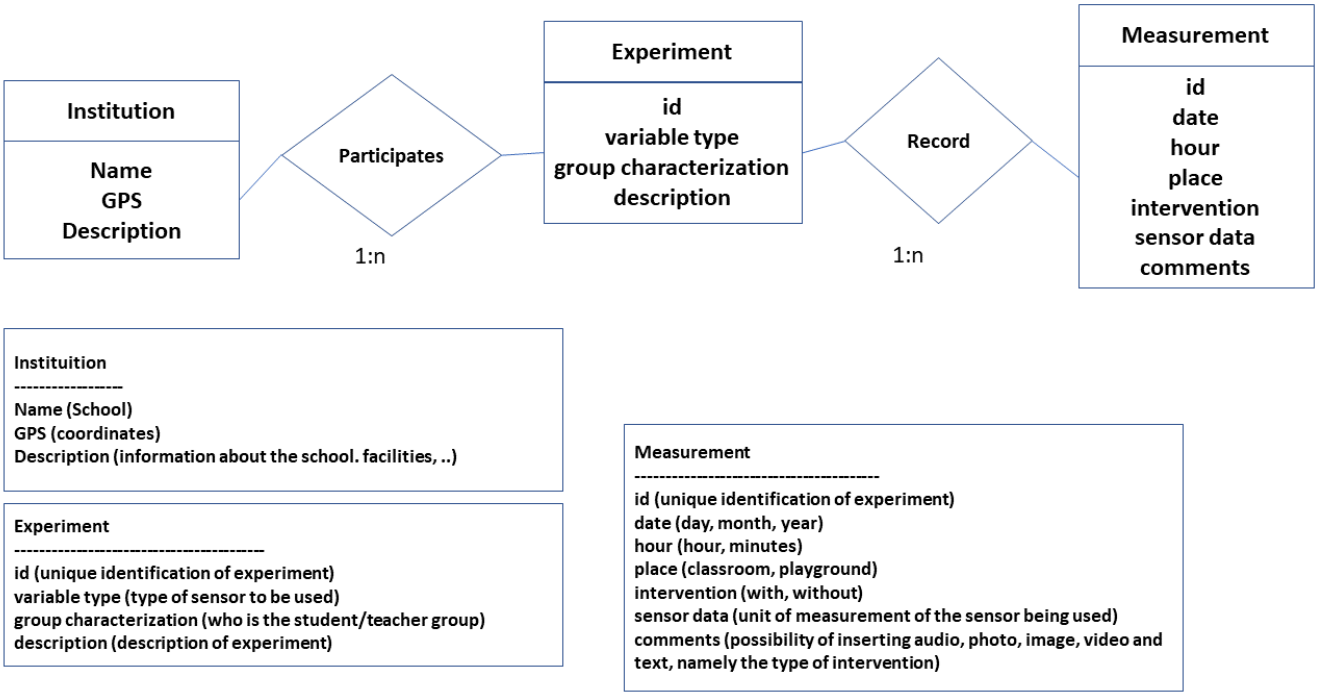

Fig. 3 – Data model

In addition to these data the Institution entity integrates information about the profile of participant schools, name, location and an institutional description.

VI. Conclusion

This paper presented the design process of a participatory environmental health education platform, the Eco-Sensors4Health platform. The Eco-Sensors4Health platform includes four main areas that were defined on the basis of the knowledge created by previous projects: a submission area, where school children can submit environmental health data, acquired by themselves with data sensors; a query area, to search for data on environmental health, acquired by school children; a school area (one for each school), with a blog and collaborative documents; an Eco-Sensors4Health project news area.

The design team works collaboratively and includes environmental education, environmental health and information and communication technologies (ICT) experts. The design process has characteristics of a design based research process. It is situated in the context of Portuguese primary schools' spaces, and of its environmental health problems, as well as in primary schools' science education curricular activities.

This way, the design process of the Eco-Sensors4Health platform is an iterative ongoing process that addresses complex problems (environmental health problems of primary schools, such as noise, air pollution, and climatic (dis)confort) in real contexts (such as Ciência Viva School,CVS, a science museum primary school). In the experiments developed in CVS, teachers/researchers and students were active partners in identifying, studying and purposing solutions to school environmental health problems, while iteratively using data forms to be included in the platform. The collaborative documents that will be developed by teachers and children, and made available in each school area, portray the environmental health inquiry process, and were based on experiment plans, used, and validated, in previous research studies.

Future work includes the implementation of the platform, and its use in case studies, as a proof of concept. The use of the platform will be evaluated through the assessment of the improvements in schools' environmental health and of children's health, environmental, and technological learning outcomes.

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