The Smart Wind Turbine Lab

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***Abstract*—Remote experimentation is at the core of Science Technology Engineering and Mathematics education supported by e-learning. The development and integration of remote laboratories in online learning activities is hindered by the inherited supporting infrastructure's architecture and implementation. In this paper we present a remote experiment (The Smart Wind Turbine) built following the Smart Device Paradigm and integrated in an Inquiry Learning Space: the rich open educational resource defined in the EU project Go-Lab. Graasp- an educational social media platform, is the authoring and hosting tool. The Golabz platform is the dissemination medium among teachers and students.**

***Keywords*—Remote Experiment, Online Laboratories, Smart Device.**

I. Introduction

Remote experimentation is at the core of e-learning for STEM (Science Technology Engineering Mathematics). However, the development and broad sharing of remote laboratories (labs) is challenged by legacy technologies used at the lab and the online educational platform sides.

In Go-Lab[1], we aim at providing a complete design suite for an easy and agile creation of learning activities, encompassing all needed material in one bundle (documents, videos, labs, pedagogical structure, scaffolds, ...). The framework is composed of 2 platforms: Graasp[2] (the authoring platform) and Golabz (the sharing repository).

In Graasp, teachers assemble their resources in an ILS (Inquiry Learning Space) and share it on Golabz. Additionally, instructors can find on Golabz remote laboratories, which they can integrate in their ILS. In the framework of Go-Lab, inquiry learning is structured in five sequential phases, through which a student learns about a scientific subject. In Graasp, the ILS is a single web page, with five tabs corresponding to the inquiry learning phases through which students move as they progress in the learning scenario [1].

The Smart Wind Turbine Lab presented in this paper demonstrates how renewable energy is generated from wind. A wind turbine is subjected to wind coming from a local fan, which emulates the wind driving the turbine. It serves as an experiment to be used by pilot school teachers in the EU.

Figure 1 shows the physical setup of the lab. It is composed of the wind turbine generating electrical power, the fan emulating the wind, and the National Instrument myRIO which is the data acquisition device and the connection of the lab to the Internet.

[1]http://www.golabz.eu/
[2]http://graasp.eu

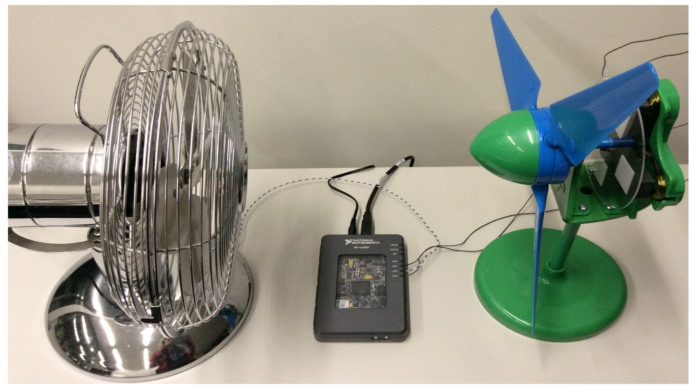

Fig. 1: The physical setup of the Smart Wind Turbine

This online lab is built and deployed following the Smart Device Specification [2]. The specification is devised in a way to support the broader sharing of remote labs, by exposing the lab resources as well-defined services. This supports the development of customised interfacing client apps, independently of the lab's implementation [3].

II. Building a Smart Remote Lab

In [4] the authors strive to equip labs' instrumentation with communication and computation capabilities, by abstracting their physical properties and dynamic behaviours as services. The result is a well-defined API that allows the diversity of client applications for interfacing with the same remote lab. Not only differently designed applications can communicate with the same lab, but they can also be differently implemented (technologies used).

The figure below describes how the Smart Wind Turbine Lab is connected to the Internet:

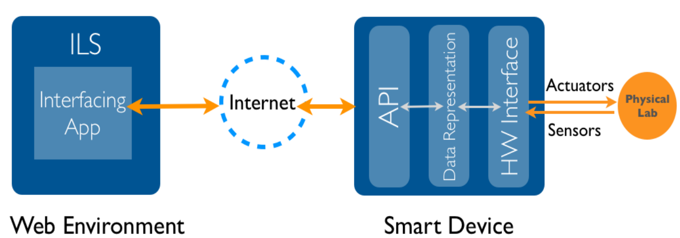

Fig. 2: The System's Architecture

Figure 2 depicts the abstraction of the physical properties and operations of the lab equipment, by categorising the components as 'sensors' or 'actuators'. Typically this is dictated by the direction in which information flows between the Smart Device and the Physical Lab. The fan emulating the wind is an actuator that can be controlled at distance by the students (turning it on or off and controlling its voltage). The wind turbine's voltage and RPM, as well as the video camera are sensors because their states are measured by the Smart Device. We are also considering to add an anemometer as sensor.

The first stage towards the interaction with a client app through the Internet is to collect/supply data from/to the physical devices and translate it to software readable formats. We build our hardware interfacing module using LabVIEW[3] on a myRIO[4] device from National Instruments[5] (NI). This choice is based on the easy and fast development and deployment of data acquisition solutions using this NI system engineering suite.

The acquired data is then abstracted as services in the form of an API that defines the lab's functionalities as methods. So the data arriving from the hardware interfacing module is modelled by attributing to it properties and access points in structured JSON objects: the 'metadata'. The metadata as defined in the Smart Device Specification follows the API as detailed in [4]. This lab's metadata can be found here: https://github.com/go-lab/smart-device/tree/master/myRIO/wind-turbine-interplay/metadata.

The communication channel between the Client App (user) and the Server App (lab) is established through WebSockets by message exchange. This solution is both efficient and easy to implement on the client side.

III. Developing the Client Application

In this section we will explain the development of the client application and its integration in an ILS.

Our target platform in this paper is Golabz, so we will build our client app as an OpenSocial (OS) app[6].

The OS web app is written in javascript. As mentioned before, the interaction with the lab server is insured by WebSockets that forward service calls to their respective API blocks by 'message' matching.

In this implementation of the app, the user can turn on or off the fan with a button. The student can also increase/decrease the wind speed by moving up and down the slider adjusting the power supply of the fan. The generated voltage is displayed as well as the RPM (Revolutions Per Minute) of the turbine. Dynamic bars grow and shrink as the voltage and RPM increase/decrease respectively. With the collected data, the student can plot the wind speed (proportional to the power supply of the fan or measured with an anemometer) vs. the power generated by the wind turbine. This helps in identifying parameters of the system, such as the cut-in speed (the wind speed at which the turbine starts turning), rated output power (the maximum power the system can generate), and rated speed (the speed beyond which the system is saturated).

Having this application, teachers can now create their learning activity in the form of an ILS on Graasp. In the ILS different resources are interleaved on one web page, and grouped in sequential phases of the inquiry learning scenario [1]. The figure below describes the integration of the web app in an ILS:

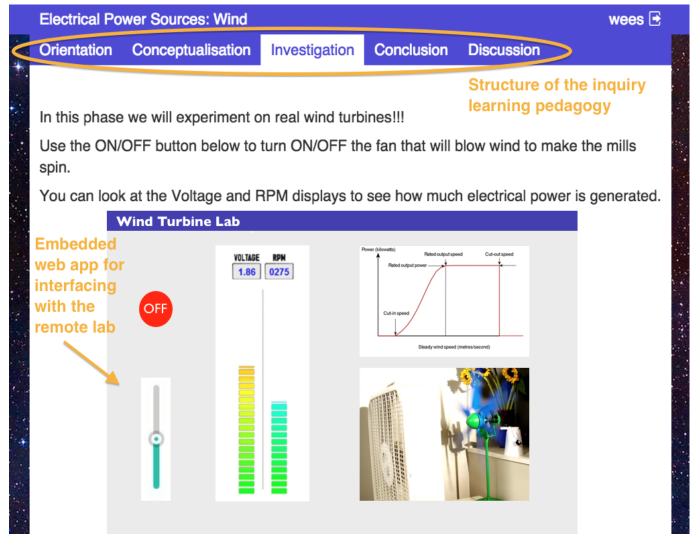

Fig. 3: Mock of the Web App Integration in an ILS

IV. Conclusion

We presented in this demo paper how to build a 'Smart Lab' following the Smart Device Paradigm, how to interface it for the users using an OpenSocial app, and how to integrate it as an inquiry learning space. This framework for developing and deploying remote labs on Golabz can be considered as an open, rich, and flexible medium for sharing and reusing remote labs. This is made possible by the decoupling of the server and client side of the remote lab architecture, and the exposure of the physical lab as well-described services.

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References

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