

## Chapter 28

# Web 2.0 Open Remote and Virtual Laboratories in Engineering Education

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### ABSTRACT

*This chapter presents challenges in deploying remote and virtual laboratories as open educational resources with application to engineering education, as well as current trends in using Web 2.0 technologies to enable broader adoption and ease of development. The Spanish initiative to establish a common remote and virtual experimentation infrastructure between various universities is presented as an example of an open laboratory network. This example shows the benefit of sharing complex educational resources. The difficulties that impair the adoption and dissemination of current remote experimentation environments are then analyzed. Smart devices and widgets paradigms are proposed to transform current remote laboratories into new user manageable social entities. The Internet of Things and the Web of People concepts are introduced as a framework for further investigating collaborative, active, and social learning environments. This framework is illustrated in the context of a control course in which smart devices are interfaced through widgets integrated into personal learning environments and shared in a flexible and agile way by the learners.*

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## 1. INTRODUCTION

In the last two decades, the engineering education community has carried out numerous initiatives to develop and implement remote and virtual laboratory activities in higher education. This trend resulted concomitantly from the availability of innovative software packages for instrumentation and simulation, as well as the necessity to better support active and collaborative learning. Remote and virtual laboratories correspond to online equipment and simulation tools, respectively. They can be accessed through a Web browser for experimentation carried out either individually or in teams.

Freely accessible remote and virtual laboratories belong to a special class of open educational resources (OER). This is due to the fact that they are not simple digital artifacts. First of all, they cannot be moved from one repository to another or copied on the learners' computer. Typically, virtual laboratories rely on computer clusters and local simulation package licensing schemes which bind them to a given provider for hosting and execution. Remote laboratories are associated with physical and sometimes expensive laboratory equipment that is also bound to a given provider. Second, these educational resources are more complex than typical multimedia resources. The exploitation of virtual and remote laboratories enables students to produce new digital artifacts that can be shared, such as simulation results or measurements in form of graphs or data collections. In that sense, virtual and remote laboratories can be considered as active OER. Third, virtual and remote laboratory are pedagogically agnostic, in the sense that the same resources, such as a small remotely accessible robot, can be exploited by a school teacher to develop interest in science for K12 kids or by a university professor to illustrate advanced topics in robotics. Finally, they cannot be copied (only physically replicated). This makes virtual and remote laboratory easier to be openly shared without copyright infringement risk. How-

ever, they require local maintenance and energy to be exploited. Hence, there is an actual cost associated with user accesses. Never the less these facilities<sup>1</sup> are often open to the outside world at no cost when not used internally, i.e at night. The challenges of deploying and sharing such OER are details in this chapter.

Nowadays, a few universities provide access to remote or virtual laboratory facilities in a blended learning framework. However, this paradigm has not spread as broadly as anticipated initially because of the high overhead for development, the difficulty of integrating the developed stand-alone solution in learning management systems (LMS), and the associated exploitation and maintenance costs (Salzmann & Gillet, 2007). Moreover, each piece of online equipment has its own instrumentation and sensing devices to be interfaced. Similarly, each simulation relies on specific models and animations to be built. This lacks of standards refrains the spread of remote or virtual laboratories.

Fortunately, Web 2.0 technologies and agile development and deployment approaches us enable to tackle these challenges. New lightweight protocols such as RSS feeds can be exploited to share experimentation data. HTML 5 Web sockets can be used to provide efficient real-time communication between client and server applications. High-quality user interfaces can be developed using AJAX, SVG, and new HTML 5 items. Specialized open-source authoring tools (such as Easy Java Simulations, Christian & Esquembre, 2007) make it easy for instructors to create or adapt, from freely available digital libraries, existing simulations for virtual and remote experimentation. Remote and virtual laboratory resources can then be shared, improved, reused, and mashed up thanks to open educator communities relying on social media platforms. Students can easily find relevant resources and peers to carry out labs that fit their needs and skills.

In this chapter, we first show in Section 2 how laboratory facilities have evolved from local to

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