Analysis of Integration of Remote Laboratories for Renewable Energy courses at Jordan Universities

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Abstract—MUREE project aims at the development of courses for training specialists about renewable energy production by combining face-to-face learning with on-line attendance. In this sense, remote laboratories are nowadays essential for distance education, even more within MUREE project, since Jordan students are not able to use face-to-face traditional laboratories due to their different physical location. These remote laboratories can be employed by instructors within their virtual classrooms, so that students can carry out their on-line experiments from anywhere and at anytime. For MUREE project, remote laboratories are seen as pedagogical elements that must be fully-integrated into a the learning/teaching process. Therefore, this work focuses its attentions toward the integration of remote laboratories into Learning Management Systems (LMSs) and, additionally, discusses the advantages and disadvantages of this approach.

Index Terms—Distance Education, Remote Laboratories, Online Experiments, Learning Management Systems (LMSs).

I. INTRODUCTION

Within the field of Engineering Education making practical experiments is essential, as an accompaniment to magisterial classes, in order to enforce theoretical and practical concepts. This task is much more complicated in distance education, since students attend mainly to virtual classes. Therefore, the use of remote laboratories can help them to minimize this inconvenient. In addition to this, online evaluation experiments will help instructors to prepare suitable evaluation on-line experiments, in similar conditions as students are in the same physical location as the real laboratory.

According to this, the main objective of the MUREE project [1], which supports this work, is the development, integration, accreditation, and evaluation of renewable energy courses in the context of Engineering degrees from several universities in Jordan. This project follows the guidelines proposed by the Bologna process, and considers the previous experimentation with renewable energy equipment, in order to allow us to study the best approximation of remote laboratories.

Institutions can desire to share their laboratories by means of the integration of laboratories into shared courses among different universities, avoiding the need to reproduce the same deployment in each institution. The sharing of laboratories, not only cost, but also allows students to have a wider offer of laboratories. So, this is a key element for choosing a particular integration methodology for this project. From the MUREE project perspective, the integration of the remote laboratories into a Learning Management System (LMS) satisfies the need of pedagogical support for experimentation. There are different methodologies to perform this task in the literature which will be explored in this work, thus finding out the most suitable for our purposes.

In this work we pay attention to the main three ways of integration of remote laboratories into LMSs. The first approach is based on the use of middleware that expands the capabilities of the remote laboratories. This middleware is known as Remote Laboratories Management Systems (RLMSs). The second analysed approach is the extension of learning content standards to include the remote laboratories. Finally, the most suitable approach from the perspective of this project is the use of the extension mechanism provided by LMSs themselves. The main advantages and disadvantages of three approaches are explained in the following sections. Finally, the main benefits of the chosen approach are detailed.

The rest of this paper is organized as follows. In Section II, the most popular laboratories are described. Section III analyzes how to perform the integration of remote laboratories into learning environments. The discussion about the main benefits of integrating remote laboratories into LMSs is detailed in Section IV. Finally, Section V highlights our final remarks and suggests guidelines for future work.

II. REMOTE LABORATORIES

A remote laboratory is a software and hardware equipment that allows students to remotely access real devices located at a particular institution. Users access this equipment as if