

Remote Laboratories for Renewable Energy courses Courses at Jordan Universities

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Abstract—In the field of Engineering Education, performing practical experiments is essential, as an accompaniment to magisterial classes, in order to enforce theoretical and practical concepts. This task is much more difficult in distance education since students attend mainly to virtual classes. Therefore, the use of remote laboratories can help minimize this inconvenient. In addition, remote laboratories may help teachers to prepare suitable evaluation on-line experiments, in similar conditions if students were physically in the real laboratory, on the other hand, remote laboratories can be a good complement to real experimentation, as a preparatory step, preparing them to face similar tasks in the immediate future.

Accordingly, the principal objective of the European TEMPUS project entitled “Modernizing Undergraduate Renewable Energy Education: EU Experience for Jordan”, which supports this work, is the development, integration, accreditation, and evaluation of a renewable energy course in the context of engineering degrees from several universities in Jordan. This project follows the guidelines proposed in the Bologna process, and considers the previous experimentation with low-cost renewable energy equipment in order to allow us to study the best approximation of remote laboratories. This is a previous step before addressing this task with complex and expensive equipment.

Keywords—low-cost remote laboratories;renewable energy

I. INTRODUCTION

A remote laboratory is a software and hardware instrument which allows students to use real tools through the Internet [1]. In this sense, distance education students are able to perform on-line experiments from anywhere and at any time as if they were physically at the local institution. Additionally, the remote laboratory can be available all time; 24 hours a day, 365 days per year, except during maintenance task. On the other hand, remote laboratories can be a good complement to real experimentation, as a previous step, preparing them to tackle similar tasks in the immediate future.

What is more, institutions can desire to share their laboratories by means of the federation of laboratories, avoiding the need to reproduce the same deployment in each

institution. The sharing of laboratories, not only reduces cost, but also allows students to have a wider offer of laboratories. Several studies are found in the literature ([2], [3], [4]) which detail how well remote laboratories can help teachers in the learning/teaching process.

However, regarding with the task of designing and implementing a remote laboratory, we can find two different approaches: the use of low-cost simple devices to permit the easy replication of them in other institutions, or the utilization of expensive systems with a complex deployment, but with a higher amount of sensors and actuators.

In 2013 the MUREE, [5], Modernizing Undergraduate Renewable Energy Education: EU Experience for Jordan, Tempus project started. The wider objective of MUREE is to develop, integrate, accredit and evaluate a quality bachelor degree program in Renewable Energy (RE) in Jordan with an appropriate laboratory component jointly taught by universities in Jordan, in accordance with the Bologna process.

Since the economic resources are reduced, the Muree project also take into account the idea of federation of the educational resources among the Jordan Universities, allowing, specifically, the use of a set of renewable remote laboratories.

Hence, this paper proposes the hardware and software implementation of low-cost remote laboratories using Lego Mindstorms NXT v2.0, for solar and wind renewable energy in the frame work of a resource federation in the MUREE Project as a previous step before dealing this task with complex and expensive equipment. These remote laboratories have been developed, following the philosophy of Laboratories as a Service (LaaS) ([6], [7]), an original approach that allows teachers to design multiplatform laboratories

II. MUREE PROYECT

A. Brief description of MUREE goals

The MUREE project, [5], foresees the development and implementation of a new national undergraduate degree programme in renewable energy (RE) in the Jordanian