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IEEE Standard for Networked Smart Learning Objects for Online Laboratories

IEEE Education Society

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IEEE
3 Park Avenue
New York, NY 10016-5997
USA

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IEEE Standard for Networked Smart Learning Objects for Online Laboratories

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Abstract: Methods for storing, retrieving, and accessing online laboratories as smart and interactive learning objects are defined in this standard. For this purpose, the first level of the standard offers any online laboratory (lab) as a service (Lab as a Service or LaaS). The standard also defines methods for integrating online laboratories as smart learning objects in learning environments and learning object repositories.

Keywords: IEEE 1876™, Lab as a Service (LaaS), learning environment, learning object repository, metadata for learning resources, mobile laboratory, mobile learning, networked learning environments, online distributed simulations, Open Educational Resources (OER), online laboratory, online laboratory architecture, online laboratory brokerage, open laboratory, remote laboratory, Science, Technology, Engineering, and Mathematics (STEM) Education, smart device, virtual laboratory

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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Introduction

This introduction is not part of IEEE Std 1876-2019, IEEE Standard for Networked Smart Learning Objects for Online Laboratories.

Laboratory activities in support of Science, Technology, Engineering, and Mathematics (STEM) Education aim at attaining pedagogical goals and developing engineering skills. Laboratory activities can nowadays be carried out online, thanks to information and communication technologies (ICT). Such online laboratory activities rely on networked electronic devices such as personal devices (desktop computer, laptops, digital tablets, or smartphones), as well as Internet of Things devices (such as connected sensors and actuators).

Online laboratories for STEM education are educational ICT systems. They are becoming more and more popular. In many cases, an online laboratory experiment consists only in remotely interacting with devices over computer networks without necessarily reflecting the educational objectives that underlie the activities. This standard establishes the relationship between all the components (hardware, software, and learning environments) in order to ease the design and implementation of pedagogically driven online laboratory activities. This standard is designed to ease the design, the implementation, and the usage of pedagogically-oriented online laboratories as smart learning objects and their integration in learning environments and learning object repositories.

Figure 1 illustrates the implementation layers of online labs as smart learning objects that are considered hereafter for standardization. The first layer standardizes an online Lab as a Service (LaaS), which can be personalized at the second layer. The second layer describes an online Lab as a Learning Object (LO), which can be integrated in various learning environments, including massive open online courses (MOOCs), learning management systems (LMSs), learning resources repositories, and mobile applications.

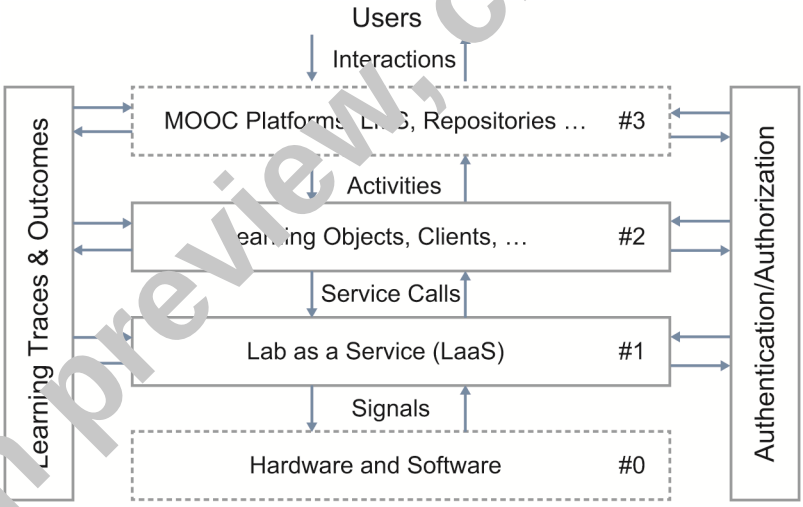

Figure 1—Conceptual layers and normative information

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IEEE Standard for Networked Smart Learning Objects for Online Laboratories

1. Overview

1.1 Scope

This standard defines methods for storing, retrieving, and accessing online laboratories and associated data as smart and interactive learning objects. For this purpose, the standard does so within the context of defining an online laboratory (lab) as a Lab as a Service (LaaS). The standard also defines methods for integrating online laboratories as smart learning objects in learning environments and learning object repositories. Finally, this standard demonstrates, through use cases, how adhering to the methods defined herein can satisfy pedagogical objectives.

Within the context of this standard, LaaS is defined as a set of interface requirements to be met to satisfy the first level of standardization. This provides a standard interface. Once this interface is established, an online laboratory should fit within learning frameworks as a Learning Object to provide pedagogical value. This capability, however, is not something that can be guaranteed. Therefore, the second level of standardization is defined as a set of recommended practices.

1.2 Purpose

The purpose of this standard is to ease the design, implementation and use of online laboratories for education. It is understood that laboratory activities are required in Engineering, Science, and Technology Education. Laboratory activities aim at fulfilling pedagogical objectives and developing experimental skills. Laboratory activities can nowadays rely on digital education solutions. Such solutions generally integrate networked electronic devices such as computers (desktops, laptops, tablets, and smartphones) as well as networked measuring instruments or electromechanical devices. Online laboratories for education are technology enhanced learning resources. They are becoming more and more popular. This standard defines and establishes the relationship between all the components required to carry out pedagogically sound experiments using laboratories (equipment, software, hardware, and services). The standard aims at facilitating the work of lab owners when setting up and sharing online laboratories; the work of platform managers when offering and enabling the exploiting of online laboratories as learning objects; the work of teachers when integrating and implementing an online laboratory in their pedagogical scenarios; and the work of learners when interacting and learning with online laboratories.