Chapter 18
Designing an Intelligent Virtual Laboratory Using Intelligent Agent Technology

Saima Munawar
NCBAE, Pakistan & Virtual University of Pakistan, Pakistan

Saba Khalil Toor
Forman Christian College University, Pakistan

Muhammad Hamid
NCBAE, Pakistan & Virtual University of Pakistan, Pakistan

EXECUTIVE SUMMARY
This chapter examines virtual laboratories and describes a design architecture of an intelligent lab companion (ILC) agent for intelligent virtual laboratories (IVL). A virtual laboratory is a stimulating aspect in spreading practical education based on online web experimentation in distance and blended education. It can facilitate and improve the practical and investigation learning of students.

INTRODUCTION
Hands-on technical learning requiring students to be in a laboratory is a core pre-requisite skill of science and technology fields like computer science, engineering, and the pure sciences. There are two types of laboratories namely, actual and virtual laboratory (VL) (Elawady & Tolba, 2009). Whilst actual laboratories have their strengths and challenges, virtual laboratories (VLs) have an added advantage over the actual in that they allow room for maximizing the use of technology for adaptive learning to be built in to support customized learning.

Uludag, Guler, Karakus, & Turner (2012) have described that since the physical laboratory set-up is expensive, to meet the laboratory needs they introduced a virtualized infrastructure whereby two computer courses for implementing an operating system and network were created. It is commonly accepted
that learners can be more engaged when they apply their own practical concepts of different fields in an
adaptive learning system (Heffernan & Heffernan, 2014; Kardan, Aziz, & Shahpasand, 2015; Nye, 2015).
An intelligent virtual laboratory (IVL), in particular, has a further advantage to a VL in that artificial
intelligence (AI) techniques and applications such as the Cognitive Tutor (Ritter, Anderson, Koedinger,
E., Dabbagh, N., & Kalbfleisch, M. L., 2008), ALEKS (Reddy & Harper, 2013), ASSIST (Heffernan,
and PACA provide a more assistive “hand” to students who are learning remotely on their own (Munawar,

In order to create a more intelligent VL, an exploratory research related to computer laboratory was
conducted to evaluate how current facilities and tasks of a computer laboratory can be capitalized to
improve students’ learning in their applied undergraduate and graduate courses. The purpose of this
study was to understand and evaluate how existing services of computer laboratory work are enhancing
students’ learning in their practical coursework. The students’ answers or responses were helpful in
improving computer laboratories for better understanding and learning experience. Data collection of
the computer laboratory evaluation questionnaire was drawn on both quantitative and qualitative methods.
The qualitative data were also analyzed to overcome the students’ problems and get ahead to further
enhance and understand students’ views. The questionnaire had been distributed to students in the Uni-
versity of Pakistan and institutions in rural areas of Punjab in Pakistan who are learning using online and
different modes of learning such as conventional, e-learning, blending and distance learning institutions.

This exploratory research also tested students’ practical skills as well as investigative - based learn-
ing in a computer laboratory environment. The findings from the research were used to design a learn-
ing environment where artificial intelligent agents were designed and incorporated into the system to
resolve the students’ problems while enabling them to perform practical course tasks. There are some
comments illustrating the challenges of technological enhancement of laboratory tasks as perceived
by the research participants. These challenges include latest scientific deviations, software problems,
curriculum changes, student competency, equipment failure and software inconsistency, lack of com-
munication between expert teachers in particular courses. Further, there is lack of adequate training for
students, didactic instructions, group discussion platform, clash in laboratory usage time, programming
incompetency such as a problem in understanding of coding, advanced computations, and concept un-
derstanding (how to approach from problem to solution, error detection and handling especially logical
errors). We had to propose an IVL that can provide a solution to these challenges and those faced in the
physical laboratory faced be employed to overcome these encounters.

To facilitate the design of an IVL, the survey results were used in tandem with previous work by
the authors, namely the Pedagogical Agent-based Cognitive Architecture (PACA). The PACA was built
according to cognitive architecture segments such as short - term and long- term memories, sensory,
perception, attention memories and action selection based on procedural memory. The IVL can be further
designed based on the proposed PACA. The proposed research describes the IVL based on PACA which
can be employed as a research laboratory assistant that has the ability of self-regulating learning to aid
pupils in the practical tasks of computer skills (Munawar, Toor, Aslam, & Hamid, 2018).