Designing an Intelligent Virtual Laboratory Using Intelligent Agent Technology

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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, & Corbett, 2007), Cognitive Constructo (Samsonovich, A. V., De Jong, K. A., Kitsantas, A., Peters, E. E., Dabbagh, N., & Kalbfleisch, M. L., 2008), ALEKS (Reddy & Harper, 2013), ASSIST (Heffernan, N. T., Turner, T. E., Lourenco, A. L., Macasek, M. A., Nuzzo-Jones, G., & Koedinger, K. Ret al., 2006) and PACA provide a more assistive "hand" to students who are learning remotely on their own (Munawar, Toor, Aslam, Enriquez, & Hamid, 2017).

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 University 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 learning in a computer laboratory environment. The findings from the research were used to design a learning 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 communication 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 understanding (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) .

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