Chapter 23
An Intelligent Approach for Virtual Chemistry Laboratory

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ABSTRACT

Formal learning has shifted from the confines of institutional walls to our home computers and even to our mobiles. It is often felt that the concept of e-learning can be successfully applied to theoretical subjects but when it comes to teaching of science subjects like chemistry where hands on practical training is must, it is inadequate. This chapter presents a hybrid approach (amalgamation of concepts of machine learning technique with soft computing paradigm) to develop an intelligent virtual chemistry laboratory (IVCL) tool for simulating chemical experiments online. Tool presents an easy to use web based interface, which takes as input the reactants and presents results in the form of - type of reaction occurred and the list of possible products. Technically, the IVCL tool utilizes naïve bayes algorithm to classify the type of reactions and then applies genetic algorithm inspired approach to generate the products. Subsequently it employs system of equations method to balance the reactions. Experimental evaluations reveal that proposed IVCL tool runs with 95% accuracy.

1. INTRODUCTION

The emergence of Internet and information technologies has given an unprecedented boost to e-learning. Learning over internet has added a new dimension to traditional education system. It has enabled the learners to not only access the educational resources across the globe but also interact with others and engage in effective and attractive learning experiences (Welsh et al., 2003). Recent findings of Project Tomorrow (2014) revealed that 50% of middle school students who took online classes apart from their

DOI: 10.4018/978-1-5225-8179-6.ch023

regular school level felt that online learning makes it easier for them to succeed. Around 50 percent of virtual high school students preferred their way of learning in school and32 percent of traditional high school students also preferred the e-learning mode. It was also observed that 53% of students wanted their schools to allow them use their own mobile devices to support their schoolwork. These e-learning systems seek to bridge the digital divide i.e. to fill the gap in the skills of teachers and learners and focus on providing the facilities of online teachers / mentors and virtual laboratories to implement the taught theory in the virtual world. For example massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as videos, readings, and problem sets, MOOCs facilitates the interactions of the users with students, professors, and teaching assistants, thereby forming the virtual communities (Pappano, 2014; Lewin, 2013). EdX (https://www.edx.org) provides a platform for students and institutions seeking to transform themselves through cutting-edge technologies, innovative pedagogy, and rigorous courses. Coursera (https://www.coursera.org/) is an education platform that partners with top universities and organizations worldwide, to offer free online courses. MIT OpenCourseWare (OCW) (ocw.mit.edu) is an open web-based publication of virtually all MIT course content and is available to the world. OCW enables the educators to improve courses and curricula, making their schools more effective. Students find additional resources to help them succeed and enrich their lives by tackling difficult challenges. Open Yale Courses (oyc.yale.edu) provide free and open access to a selection of introductory courses taught by distinguished teachers and scholars at Yale University. Thus, this digital era has completely transformed the conventional teaching and learning styles. Although a big advantage, these platforms provide only the course materials to be studied and understood by the students without any practical experience. However learning theory without practice is like body without soul. Laboratory experience is a key factor in technical and scientific education. The concept of ''learning by doing'' (Bruner, 1990) emphasizes that laboratories are important components of education to make students to gain experience. The importance of laboratory experience in engineering education (and other fields) has long been recognized such that experimental skills are considered crucial in the sciences as well as computer science (Tichy, 1998). Thus in this era of technology assisted education, virtual laboratories are indeed essential for the students. Virtual Laboratories concept was defined as "laboratory experiment without real laboratory with its walls and doors. It enables the learner to link between the theoretical aspect and the practical one, without papers and pens. It is electronically programmed in computer to simulate the real experiments inside the real laboratories." (Harry & Edward, 2005). Woodfield (2005) defined virtual laboratories as the learning environments in which students convert their theoretical knowledge into practical knowledge by conducting experiments. In addition, it was defined as "A virtual studying and learning environment aims at developing the lab skills of students. This environment is located on one of the internet pages. Usually, this page has main page & many links, which are related to laboratory activities and its achievements (Zaitoon, 2005). These laboratories provide an opportunity to the students to repeat any incorrect experiment and deepen the intended experiences (Ardac & Akaygun, 2004 Jeschke, Richter, & Zorn, 2010). Thus, virtual laboratories offer the learning experience of a physical laboratory without the limitations of time, location, material and equipments (Harding, 2003). It was also emphasized that virtual laboratories are not only beneficial from the organization and economic point but also enhance learning of the students (Wolf, 2010). Virtual Laboratory concept has been expanded to advanced opportunities for integrated teaching, research and promoting cross-disciplinary research (Rauwerda et al., 2006). Studies have been performed to identify what students can learn from virtual labs. Results indicate that students found virtual lab experiments likeable, easy and quick to do (Wendy &