Abstract

One of the critical features of Computer Science and Engineering (CSE) education is learning by doing. The rapid upsurge in the use of Internet has drawn attention to the importance of online laboratory-based learning in CSE education. However, bringing such experiences online is challenging. Contextually, enabling online virtual lab-based learning is a modern trend in many educational institutions. So, online laboratory-based learning has emerged as a popular area of research among learning technology researchers. In an online laboratory learning environment, the instructor has significantly reduced role, and students take increased responsibility for their learning. This shows that in online lab-based learning, the involvement of students is higher. Traditional classroom-based laboratory learning has many limitations. The necessity to engage students in self-learning through online laboratory learning is imminent, as the students get an opportunity to perform their laboratory experiments beyond the classrooms as well, such as at home or when on vacation.

Due to the rapid growth of software development, it becomes essential to have hands-on experience on software development at the undergraduate level. Concurrently, it is also important to measure students' performance in an online environment. It is reported in the existing literature that students' grades are the most measurable learning outcomes. However, such grades may not be properly indicative of students' learning effectiveness. Grades may not be reliable learning measurement tool for the assessment of performance due to the inherent inconsistency that underlie the grading process. In this case, a self-design tool may add learning gains and outcomes in a consistent manner.

To investigate these issues, a Software Engineering Virtual Lab (SE VLab) (*http://virtual-labs.ac.in/cse08/isad/*) was developed for engineering students at the Indian Institute of Technology Kharagpur with funding from the Ministry of Human Resource Development (MHRD), Government of India (GoI). This laboratory exposes students to various fundamental topics related to Software Engineering. In a traditional laboratory environment, the evaluation process is inherently deficient, subjective, and subject to unfairness with possibilities of bias. In this Thesis, we discuss a novel approach for evaluating learning gains and learning outcomes. We developed a tool for measuring the effectiveness of virtual learning. The results are validated statistically. We also evaluated the SE VLab in different pedagogical contexts using the developed tool. Results show that the designed SE VLab is more effective than similar traditional SE labs in terms of learning gains.

Keywords: *Software Engineering, Virtual Laboratory, Computer Science Engineering Education, Evaluation, Learning Outcomes.*