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Virtual Lab

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Abstract

Virtual labs for science experiments are a multimedia technology innovation. A possible growth pattern of the perceived critical mass for virtual labs adoption is modelled using (N=240) potential-adopter teachers based on Roger's theory of diffusion and of perceived attributes. Results indicate that perceived critical mass influences behaviour intention to adopt a technology innovation like Virtual Labs and is affected by innovation characteristics like relative advantage, ease of use and compatibility. The work presented here models the potential-adopter teacher's perceptions and identifies the relative importance of specific factors that influence critical mass attainment for an innovation such as Virtual Labs.

Keywords: Virtual labs innovation diffusion critical mass simulation lab experiments.

The Philosophy

Good lab facilities and updated lab experiments are critical for any engineering college. Paucity of lab facilities often make it difficult to conduct experiments. Also, good teachers are always a scarce resource. The Virtual Labs project addresses this issue of lack of good lab facilities, as well as trained teachers, by providing remote-access to simulation-based Labs in various disciplines of science and engineering. Yet another objective is to arouse the curiosity of the students and permit them to learn at their own pace. This student-centric approach facilitates the absorption of basic and advanced concepts through simulation-based experimentation. Internet-based experimentation further permits use of additional web-resources, video-lectures, animated demonstrations and self-evaluation. Specifically, the Virtual Labs project addresses the following:

- Access to online labs to those engineering colleges that lack these lab facilities.
- Access to online labs as a complementary facility to those colleges that already have labs.
- Training and skill-set augmentation through workshops and on-site/ online training.

Virtual labs are any place, any pace, any-time, any-type labs. It is a paradigm shift in student-centric, online education.

Objectives

1. To provide remote-access to simulation-based Labs in various disciplines of Science and Engineering.
2. To enthuse students to conduct experiments by arousing their curiosity. This would help them in learning basic and advanced concepts through remote experimentation.
3. To provide a complete Learning Management System around the Virtual Labs where the students/ teachers can avail the various tools for learning, including additional web-resources, video-lectures, animated demonstrations and self-evaluation.

Overview

Virtual Labs project is an initiative of Ministry of Human Resource Development (MHRD), Government of India under the aegis of National Mission on Education through Information and Communication Technology (NMEICT). This project is a consortium activity of twelve participating institutes and IIT Delhi is coordinating institute. It is a paradigm shift in ICT-based education. For the first time, such an initiative has been taken-up in remote-experimentation. Under Virtual Labs project, over 100 Virtual Labs consisting of approximately 700+ web-enabled experiments were designed for remote-operation and viewing. The intended beneficiaries of the projects are:

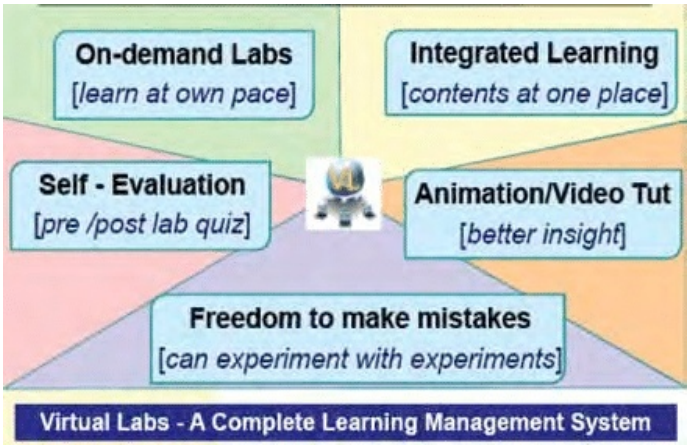
- All students and Faculty Members of Science and Engineering Colleges who do not have access to good lab-facilities and/or instruments.
- High-school students, whose inquisitiveness will be triggered, possibly motivating them to take up higher-studies. Researchers in different institutes who can collaborate and share resources.
- Different engineering colleges who can benefit from the content and related teaching resources.
- Virtual Labs do not require any additional infrastructural setup for conducting experiments at user premises. The simulations-based experiments can be accessed remotely via internet.

Broad areas of virtual labs

Virtual labs have been developed in the following broad areas:

- Electronics and Communication Engineering
- Computer Science and Engineering
- Electrical Engineering
- Mechanical Engineering
- Chemical Engineering
- Biotechnology and Biomedical Engineering
- Civil Engineering
- Physical Sciences
- Chemical Sciences

Salient features



The salient features of virtual labs are

Virtual Labs provide to the students the result of an experiment by one of the following methods, or possibly, a combination of these (see Fig 1):

I. Modelling the physical phenomenon by a set of equations and carrying out simulations to yield the result of the particular experiment. This can, at-best, provide an approximate version of the 'real world' experiment.

II. Providing a corresponding measurement data for the virtual lab experiment based previously carried out measurements on an actual system. This will be closer to the 'real world' experiment.

III. Remotely triggering an experiment in an actual lab and providing the student the result of the experiment through the computer interface. This would entail carrying out the actual lab experiment remotely.

- Virtual labs can be made more effective and realistic by providing additional inputs to the students like accompanying audio and video streaming of an actual lab experiment and equipment.

- For the 'touch and feel' part, the students can possibly visit an actual laboratory for a short duration.

In Simulation-Based Virtual Labs, the experiments are modelled using mathematical equations. The simulations are carried out remotely at a high-end server, and the results are communicated to the student over the Internet. These labs are scalable and can cater to a large number of simultaneous users.

Using the Remote Triggered Virtual Labs, the actual experiments are triggered remotely. The output of the experiment (being conducted remotely) is communicated back to the student over the Internet. This class of virtual labs gives the student the output of real-time experiments. Typically, time-slots are booked before conducting such experiments.

All Virtual Labs can be accessed through a common website: www.vlab. co.in. At the user end, a PC and broadband connectivity enables the user to access virtual labs.

E-learning resources and virtual labs

India's recent strides in information technology have propelled the growth of web-based digital learning in most disciplines of science and engineering education. Distance education and open learning endeavours offer many advantages in resource-limited developing countries, where the number of potential learners is much higher than the number of experienced teachers or advanced educational institutes[1].

However, these endeavours alone have proved insufficient in providing practical skills for science experiments or analysis of scientific data. Virtual laboratories, which act as free, round-the-clock replicas of actual laboratories, could be an effective alternative. Learners in a virtual laboratory can understand scientific theories and also experience practical experimental procedures[2,3]. As educational budgets in developing and under-developed countries continue to shrink, e-learning and open-learning programmes are gaining popularity[4].

E-learning proteomics resources

Virtual labs are rapidly changing the culture of education in developing countries[5]. India is playing an imperative role in the development of diverse e-learning resources and virtual labs in proteomics and other disciplines of biotechnology. In recent years, proteomics and related disciplines have been incorporated into academic curricula across the globe due to their increasing impact on clinical and industrial research.

The Indian Institute of Technology Bombay has developed pioneering proteomics learning resources such as the Virtual Proteomics Lab, Clinical Proteomics Remote Triggering Virtual Laboratories, and other related e-learning initiatives supported by India's ministry of human resources and development (MHRD) with a goal to disseminate high-quality educational content exclusively in proteomics[6]. The resource contains modules on gel-based proteomics, mass spectrometry-based proteomics and bioinformatics, each with a set of experiments. The course contents of Virtual Proteomics Lab have now been incorporated as a tutorial article under the

International Proteomics Tutorial Programme (IPTP 14) developed by the Human Proteome Organization (HUPO) and the European Proteomics Association (EuPA)[7].

Virtual labs for rural and urban India

A study of online statistics indicates that virtual lab users have been increasing in India. The study also suggests increasing usage trends in times to come[8].

The researchers tried to figure out the impact and penetration of virtual labs through hands-on workshops in rural South Indian biotechnology and engineering institutes and compared them with data from urban areas[9]. The feedback showed that 60% of students rated virtual labs as user-friendly tools that made their biotechnology courses interesting and easier to comprehend; 65% found virtual labs to be good online material for better understanding of the basic concepts in biotechnology and about 10% reported difficulty using them due to computer illiteracy or network connectivity issues.

Among 250 teachers surveyed, around 85% suggested that virtual labs could be used as an autonomous, supplementary learning and teaching material for enhancing laboratory education. 67% of the teachers from rural areas adopted virtual labs in their teaching while only 33% from urban areas opted for them.

Virtual labs are a technological innovation providing new learning environments for proteomics and biotechnology users. Simulation-based virtual labs can now train a huge cluster of potential researchers, who could play an important role in bioinformatics analysis of big data sets generated by scientific research labs across the world and effectively accelerate high-throughput translational research.

Virtual and open learning initiatives are poised to bring a dramatic change in science education but cannot completely substitute existing educational institutes or hands-on practical laboratory courses. Effective expansion of science education is possible by taking benefits of the affordances of both the approaches[10]. Innovative and forward-looking initiatives for distributed learning practices through e-learning and virtual labs would certainly enrich the global community of students, scientists and citizens.

Conclusion

The challenges of today's science classroom require new solutions. Technology provides one way to help science teachers overcome obstacles and improve the learning outcome. The biggest challenge lies in the laboratory, because quality lab experiences aren't being provided as often as they should be, and because the laboratory is where students have the opportunity for first-hand experience of the methods and thought processes of science. In the lab, they may emulate the activities of scientists. Most technological substitutes for labs are really just computer-based demonstrations that miss the essential elements of science methodology. The alternative presented here uses real experiments, together with interactive data collection with built-in scientific processes, to ensure that the important features of the lab are not lost. In addition, the computer software provides a means to channel the students' activities, to measure their

performance, and to support their learning. While the use of real virtual labs can result in a loss of some aspects of a traditional lab, their proper use can often more than compensate for this loss. The Smart Science system briefly described here has been in development and testing for 7 years, and has been delivered to over 30,000 students during the last 2 years. Students, and most teachers, have found it easy to use, engaging, and a valuable aid to learning science.