Assessing Students and Teachers Experience on Simulation and Remote Biotechnology Virtual Labs: A Case Study with a Light Microscopy Experiment

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Abstract. With recent trends of using Information and Communication Technologies in education, virtual labs have become more prevalent in classrooms of most schools and universities, especially in South India. The purpose of this paper was to perform a comparative analysis of virtual learning components such as animations, simulations and real-time remotely controlled experiments. As a part of this study, we conducted a series of biotechnology virtual lab workshops for University-level users within India and collected feedback related to the usage of virtual labs via direct approach. The survey amongst the students and teachers suggested simulation-based labs were more preferred in enhancing teaching and learning strategy compared to graphics-mediated animations and remotely controlled experiments. This paper also reports some of the issues faced by virtual lab users. Studies indicated that even though the web-based technologies are a new venture in education, it still poses adaptability issues.

Keywords: Virtual labs · Biotechnology · Simulation · Remote labs · Feedback

1 Introduction

In the recent years, web-based educational platforms have become popular in schools and universities and have became an integral part of modern educational system [1]. Research indicated that integration of ICT enabled e-learning technologies in conventional classroom education dramatically changed real laboratory education scenario [2–4]. Virtual laboratories provided learning materials in an easily deliverable manner to users all over the world at anytime –anywhere [5, 6] and students perceive virtual labs as an educational tool. From a teacher perspective, implementing web-based tools in classroom education have shown to reduce their work load and helped them to monitor student participation in a better way [7].

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In remote areas, students have been facing issues such as well-established laboratory with sufficient lab equipment, costly reagents, trained teachers and adequate technical support [8]. In virtual labs, animation-based labs are mainly based on multimedia representation of laboratory protocols and real-lab setup for providing a feel of real laboratory [9]. Blended approach of using animations in classroom teaching has shown to be more reliable for both students and teachers [10]. Previous studies reported that simulation-type experiments lack ability to generate real data since it does not provide access to real laboratory equipment. For that, remotely controlled experiments were developed as a complementary educational resource to hands-on labs [11]. Remote labs such as light microscopy have been popular among students in which they can effectively use the equipment and conduct experiments without being onsite. Studies also reported user adaptability in controlling remote lab set-up over the internet thus adding a new venture to distant education [11]. Various issues like multiplexed usage, noise and stability issues need to be solved to make remote lab easily accessible to users all over the world [12]. Previous studies have shown a comparative analysis of traditional labs versus virtual lab experiments [13] (see Table 1). In this paper, we highlight a comparative study on the usage of virtual lab components such as animation, simulation and remote triggered experiments amongst students and teachers for enhancing laboratory education and highlight some of the issues.

Table 1. Comparative analysis of traditional labs versus virtual lab experiments

Types of labs	Advantages	Disadvantages
Traditional labs	1. Access to real equipment	1. Scheduled lab hours
	2. Access real data	2. Need trained persons
	3. Face to face interaction with teachers	3. Cost of equipment
		4. Maintenance issues
Animation based labs	1. Visual demonstration of experiments and detailed step-by-step explanation of protocols	1. Only virtual presentation is provided to users
	2. Close proximity to real lab scenario	2. Idealistic results
	3. Easy access to labs	3. Need basic knowledge for operating computers
	4. No ethical issues	
Simulation based labs	1. High degree of interactivity	1. Understand the instructions before practicing experiment
	2. User can change the variables, which emulated real data	2. Need basic knowledge for operating computers
	3.Helps to analyze critical mistakes one could perform in a real lab set-up	
	4. Repeatability	
Remote triggered labs	1. Access to real and costly equipment	1. Network related issues
	2. Anytime access and repeatability	2. Single user at a time (Slot booking)
	3. Instrument damages comparatively low	

2 Methods

As a part of evaluating and comparing key virtualization techniques such as animation, simulation and remote triggered experiments in enhancing biotechnology education (in 2014), we conducted 6 hands-on workshops for students and 4 for teachers. A total of 250 students and 100 teachers participated in this study. The influence of virtualization techniques in learning and teaching process was analyzed via feedback.

2.1 Biotechnology Virtual and Remote Lab Workshops in India

We chose a light microscopy animation experiment, an undergraduate experiment wherein participants were allowed to learn from an animation, various parts of a microscope and its functioning. Participants were then allowed to perform a "simulation"-based light microscope experiment. They were trained to operate microscope by adjusting the fine and coarse knobs, observing various stained cells such as onion cells, cheek cells, onion root tips and different bacterial cells by changing objective lenses (10X, 40X and 100X). In remote-triggered light microscope, specimens such as plant cell and animal cell were fixed in the stage of microscope. User could operate remote microscope using an internet-enabled computer and control microscope's fine and coarse adjustments by moving a slider in GUI. Participants were trained to observe the cell and cellular components through remotely controlled microscope, adding to feel of controlling real equipment (see Fig. 1).

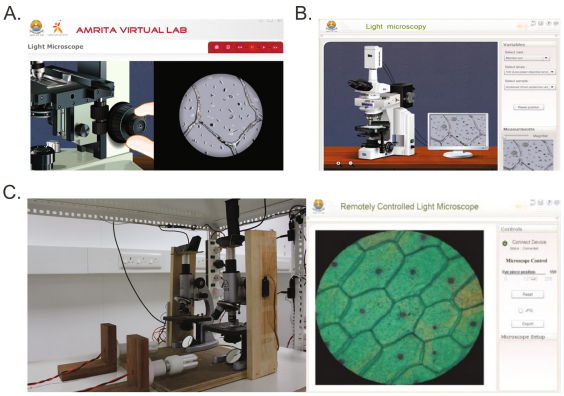

Fig. 1. A. Animation of Light microscope experiment, **B.** Simulation of Light microscope experiment, **C.** Remotely controlled Light microscope experiment (freely available via http://vlab.amrita.edu/)

The demonstration and hands on session were followed with a set of questionnaires for a comparative analysis of virtual lab components. A similar study was conducted amongst teachers to know and compare their interest in including virtual and remote lab

Table 2. Comparative analysis of virtual learning components amongst students

Sl. No.	Questions for analysis	Choices given for response
Q1	___helped to apply my theoretical knowledge into practice	Animation
Q2	__motivated me to use ICT tools in my education	
Q3	__provided a student-centered learning approach	Simulation
Q4	__are more consistent in view of easy access and realistic data	Remote trigger
Q5	___provides a close proximity to real lab experiences	

Table 3. Questionnaire based feedback to analyze the role of virtual learning techniques amongst teachers

Sl. No.	Questions for analysis	Choices given for response
Q1	__provides instructions that are able to deal with students in more interactive manner and make them to practice an experiment?	Animation
Q2	___ is helpful for you in teaching basic lab techniques easily with standardized protocols and enhance, intensify and motivate students in learning?	
Q3	___ is very helpful to teach step-by-step procedure of an experiment and prepare students to operate equipment correctly before entering to real lab	Simulation
Q4	_____ is an alternative supplementary tool that can easily access to train students at any time?	Remote trigger
Q5	_____ imitates an experiment exactly like doing in realistic lab with respect to materials and results?	

techniques in teaching process. Feedback survey collected user's preference from students (see Table 2) and teachers (see Table 3). We also included questions to analyze various limitations that create problems for students and teachers while doing experiments.

3 Results

3.1 Interactive Simulations - a Novel Platform for Current Education Scenario

Feedback analysis indicated student's preference on simulation labs compared to animation and remote triggered experiments in their learning. 48 % of students supported interactive simulations indicating that it helped them to apply their theoretical knowledge into practice. 44 % students suggested that repeated use of simulations in their learning motivated them to use ICT enabled tools in their education. 56 % of them

indicated simulation-based experiments supported student centered approach of learning since instructions provided were easy to understand. 46 % of students reported that when comparing with animation and remote triggering, simulations were more consistent in view of easy access and realistic data. 34 % of students indicated simulation labs as substitution to real lab experiences, but 56 % of students suggested they got a real feel of experiments and equipment as in a conventional laboratory education (see Fig. 2).

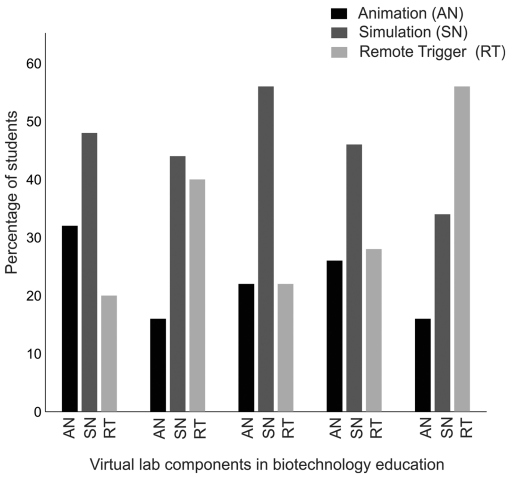

Fig. 2. Student Feedback. Questions for analysis on X-axis and percentage of users on Y-axis.

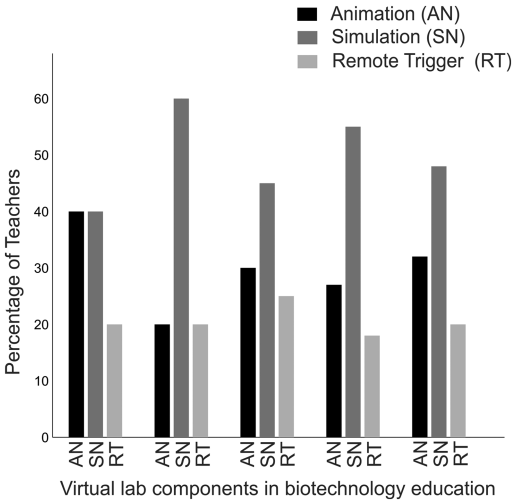

Fig. 3. Feedback of teachers. Questions for analysis on X-axis and percentage of users on Y-axis.

There was a high degree of interactivity between users and computers while performing simulations. Few users complained that they experienced network connectivity issues while doing remotely triggered experiments.

3.2 Comparative Analysis of Animation, Simulation and Remote Triggered Experiments in Teaching Biology Course

Analysis of feedback from teacher groups showed that 40 % of them suggested including both animation and simulation in the curriculum so that they could deal with students in more interactive manner and make them to practice an experiment more precisely. 60 % of teachers showed their interest on using simulations to teach basic lab techniques since they found it as an effective tool to teach the standardized protocols. 45 % of teachers would like to use simulation based experiments as a substitute for class room teaching for its step-by-step procedure of experimental protocol. 48 % of teachers suggested that simulation-based experiments as a supplementary material that can be accessed at anytime (see Fig. 3).

3.3 Analysis of Problems Faced in Virtual Lab Versus Remote Triggered Experiments

To analyze problems faced while performing animation, simulation and remote triggered experiments a questionnaire based feedback data was collected from both teachers and students (350 participants) after practicing the light microscope experiment. Feedback indicated that 80 % were able to follow animation without any difficulties while 20 % reported difficulties in performing experiment. Similarly, 85 % of participants suggested that could easily interact with simulations while 15 % faced

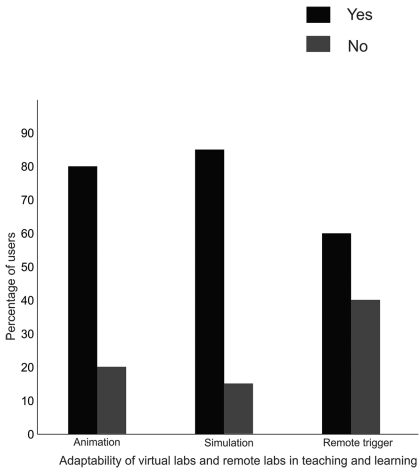

Fig. 4. Participants response on adaptability towards animation, simulation and remote triggered experiments

Table 4. Problems faced in performing virtual and remote labs in a classroom

Types of labs	Problems	User percentage
Animation	Lack of interaction	50
	No realistic output	20
	Lack of audio	21.43
	Time consuming experiments	8.57
Simulation	Difficulty in following instructions	18.87
	Need to add more variables	37.74
	Lacks touch and feel of equipment	18.87
	Computer illiteracy	24.52
Remote labs	Internet issues	50
	Lack of training	21.42
	Slot booking system	14.29
	Lacks deliverability efficiency	14.29

problems in doing experiment. 60 % of participants were able to operate remote equipment easily without the help of an instructor and 40 % of them indicated issues in using remote equipment (see Fig. 4). Most frequent issues faced by participants were identified (see Table 4).

4 Discussion

In this study, a comparative analysis on effective role of ICT enabled techniques such as animation, simulation and remote triggered experiments in learning biotechnology experiments were analyzed. We used a direct approach via organized workshops for students and teachers across various places in India. Data analyzed from overall studies indicated virtual and remote labs as a supplementary education platform for both university students and teachers to understand concepts of the experiments. Overall feedback results showed that most students preferred simulation-based experiments than animation and remotely controlled labs in their learning. Survey suggested that the usage of interactive simulators rather than animations and remote labs enhanced usage motivation in classroom education. User interaction and learner satisfaction were primary challenges while constructing ICT enabled laboratories. Our studies also revealed several problems related to usage of such labs in education. These initial results, although, suggest virtual and remote labs to be effective. We are now extending the study to understand the interaction of social, cognitive and teaching presences in a virtual scene and within traditional blended learning environments.

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