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Hybrid Lab

[*1] C Saritha,[2]Y Phanitha, [3]A Ramya Krishna
[1]Assistant Professor, Department of CSE, Bhoj Reddy Engineering College for Women, Hyderabad, India
[2,3]Students, Department of CSE, Bhoj Reddy Engineering College for Women, Hyderabad, India

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ABSTRACT

A virtual lab can be defined as a laboratory exercise performed outside of the physical laboratory. One interpretation of this includes partially virtual or take-home labs where students are led through online video demonstrations while physically conducting the experiment with a lab kit. Here we describe a hybrid virtual lab designed and implemented for undergraduate biology which offers a combination of take-home laboratory assignments coupled with in-laboratory sessions. It is an alternate option for introductory biology students which provides an opportunity to accommodate different learning styles, preferences, or needs. Although not an exhaustive list, these needs might arise from competing commitments to family, employment, sports, or the toll of long commutes. Offering flexibility in laboratory format may allow a student to better manage these conflicts and improve the quality of the overall university experience. Students retaking the biology laboratory were given an option of participating in conventional laboratories or the hybrid format. Benefits or costs of choosing between these lab formats are determined by examining the scores of students on assessments that test laboratory skills and knowledge. Performance was compared between the two groups of students through an analysis of covariance (ANCOVA), using previous laboratory scores as a covariate. Ultimately, researching virtual lab effectiveness as an alternate teaching method may create a dialogue between curriculum developers and institutions to discuss how to implement them as a way to enhance the overall student learning experience.

Keywords : Virtual Lab, Laboratory, Learning, Video Demonstrations.

I. INTRODUCTION

These guidelines include complete descriptions of the. Physical laboratories present the opportunity for science students to develop many practical scientific skills such as: interacting directly with specialized equipment, experiencing data collection, handling samples, and applying theoretical knowledge to real world situations [1]. The advance in computer technology over the past two decades has allowed

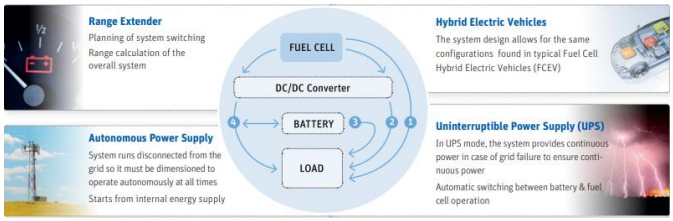
educators to simulate a physical laboratory with various materials and equipment to the point where students can virtually conduct scientific experiments [2]. However, virtual laboratories have lagged in biology, as the physical setting of a biology laboratory, and the physical manipulations that are part of the skill set to be developed, cannot easily be simulated. The vague interpretations and definitions of a virtual lab create many different online learning simulations within the literature collectively identified as "virtual labs". However, there are three types of virtual labs that are most commonly discussed in pedagogical research: remote labs, completely virtual/simulated labs, and supplemented virtual labs. In remote labs, students could conduct experiments outside of the physical lab over the internet by utilizing web applications which enable real equipment in a lab to adjust directly to feedback from the inputs and commands of the user [3]. An example of this interaction would be a student controlling a γ-ray spectrometer to analyze different elements and isotopes [3]. A potential benefit of remote labs is the reduced cost of having or maintaining specialized equipment to the institution. Students can book time slots to conduct experiments and effectively share the remote lab [4]. This approach may provide students with a good fundamental understanding of the experiments conducted, however it does not provide students with practical lab experience, nor does it develop the manipulative skills collectively referred to as "good laboratory hands". As Beverly Park Woolf, computer scientist at the University of Massachusetts Amherst stresses, students should handle the equipment, measure out a reagent, or tweak a dial [3].

In a completely virtual/simulated lab, the student conducts an experiment that is based entirely on animations, web applications, and user inputs to adjust different parameters in order to observe theoretical results with visual representations on a particular piece of technology (e.g. computer, smart phone, tablet) without coming into contact with real equipment or samples [5]. One such instance is the use of a virtual physiology of exercise laboratory program at the University of Florida (Department of Applied Physiology ad Kinesiology). Students at this institute had simulated test designs and data collection of various physiological modules as opposed to traditional hands-on lab activities [6]. The merit of this approach to virtual labs is that well designed software can be easily distributed to a large number of students while completely bypassing the need for purchasing or maintaining specialized equipment [7]. Another positive aspect of this type of laboratory is that there are no boundaries to the experiment that could be conducted. In the virtual word, reagent and equipment costs impose no limits, and vast spatial and temporal time scales are not barriers. However, a distinct shortcoming to this approach is the lack of practice in handling equipment and development of laboratory skills. A remote lab has some level of simulating real laboratory experience where students can feel like they are physically conducting the experiment; a completely virtual lab does not have this representation of the physical laboratory environment. The third type of virtual labs are supplemented virtual labs. These blend some of the simulation aspects of virtual labs, with physical experiments using take-home laboratory kits. Kits contain various equipment and materials that students must use to complete the experiments [8]. For example, students enrolled in science courses at Open University in Milton Keynes, UK have kits that might include microscopes, chemistry sets, or lasers that would be used to conduct experiments at home [3]. A merit of this approach is that the lab kits provided to students compensate the lack of handling specialized lab equipment [8]. Conversely, with a large group of students or lack of sufficient funding, providing lab kits to science students has been found to be an expensive and inefficient process [3]. This, of course, will depend on the content of the kits and the nature of the experiments.

II. PROPOSED SYSTEM

The Hybrid Energy Lab-System is a comprehensive learning and research system for hybrid energy systems with a focus on batteries and fuel cells. Designed specifical y for use inuniversities and colleges, it offers a ide range of theoretical and practical applications for the design criteria of hybrid systems with batteries and fuel cells.

The Hybrid Energy Lab-system enables various hybrid setups for Applied Research of battery and fuel cell / diesel generator systems:



Battery Modeling & Data Fitting:

The battery can be further analyzed by fitting a detailed battery model tothe data. The obtained parameters characterize the dynamic behaviour of the battery and give insight into the electrochemical processes. This analysis task is seamlessly integrated into the Application Software. Built-In and user-provided batteries can be analyzed and compared.

Hybrid Energy Management:

The Hybrid Energy Management allows a detailed real life investigation of the hybrid energy management algorithm in different phases. The connection to different sources and loads are fully configurable and allows a transparent exploration of the process.

Application Programming Interface (API):

The interface provides a simple and convenient way for the system to control data and to integrate it with other software solutions. The exchange process of data and content between different software solutions is possible and a LabView programming example from Heliocentris is also included.

III. RESULTS AND DISCUSSION

The laboratory format did have a significant effect on the overall laboratory scores for students in Winter 2016 ($F_{1,20} = 7.62$, $p = 0.012$). Studentscompleting the hybrid virtual lab students scored ~15% higher in the laboratory than studentscompleting the conventional laboratories (84% ± 4%,versus 69% ± 3%; mean ± standard error) (figure 1).A student's previous performance in the lab duringFall 2014 was not a significant predictor of success in Winter 2015 ($F_{1,20} < 0.01$, $p = 0.986$). Students contemplating dropping the course may have stopped putting forward effort at different times during the semester. Performance in Fall 2014 may have reflected this approach from students rather than student ability to perform well in the course. Student performance on laboratory knowledge andcomprehension was similarly higher for the group completing hybrid virtual labs ($F_{1,20} = 3.68$, $p = 0.044$). Students in the virtual lab section scored~14% higher than students in the conventional labsection (87% ± 3%, versus 74% ± 3%; mean ±standard error). As with overall lab score, a student'squiz average in Fall 2014 was not a significantpredictor of success in Winter 2015 ($F_{1,20} = 2.72$, $p = 0.074$).

There are many possible explanations for the stronger performance of students opting for the hybrid virtual lab format. Perhaps this format facilitated better learning of the material. Perhaps it provided students with more time, or more flexibility in when they completed labs, and this helped performance. Or alternatively it relates to a difference in characteristics of students who opted in or out of the virtual lab. A larger sample size will be necessary to make more meaningful conclusions, as only a small number of students were enrolled in the course, and only seven opted for the hybrid virtual lab format. However we have controlled for factors such as the instructor and TA. All 23 students in the analysis had the same instructor and TA. The lab quiz average analysis suggests that students opting for the hybrid lab option are not at a disadvantage in reinforcing knowledge and understanding of lab content. The analysis of overall lab scores suggest that students in the hybrid virtual lab option are not disadvantaged in developing practical

research skills. However, it would be premature to suggest that the hybrid virtual lab format is more effective than the conventional laboratory. It would be ideal to have better matched cohorts (equal numbers as opposed to 7:16) completing the hybrid virtual lab and conventional lab students in order to better control for factors that might bear on student performance, following a similar approach to a study that also investigated virtual labs [9]. It should be noted that this offering of the hybrid virtual lab was not designed as a test for the format, but rather the offering provided an opportunity to assess its effectiveness, and this is reflected in such study design deficiencies as small sample size and imbalanced cohorts.

An interesting observation to be made is that fewer students in BLG 143 exhibited interest in the virtual lab option than the conventional format. This was a surprise when the offering was made, as we expected many students would be interested in the out-of-lab format and the flexibility it offered. The students that did opt for the virtual lab format may have done so for a variety of reasons, but had confidence in their own abilities to independently learn concepts presented in the lab.

IV. CONCLUSION

Future studies of the Ryerson University approach to virtual labs should seek to obtain more quantitative data in order to make more meaningful connections between student performance and the effects of laboratory delivery format. This alternative version of the lab, lead to the enhancement of both curricula by following benefits and addressing problems faced by the other party offering two modes of the lab is that students are trained to acquire research skills rather than laboratory skills. Hybrid virtual labs give students the opportunity to learn content and complete tasks at their own pace, which follow the logic of the virtual lab providing convenience to students as opposed to the schedule of conventional labs.

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