

Merits and Demerits of Virtual Laboratories in Engineering Education

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ABSTRACT

Laboratories are important component of engineering and engineering education. With the rapid development of Information Technology (IT) or recently well-known as the Information and Communication Technologies (ICT), virtual laboratories are used as an alternative or a supplement to the physical or real laboratories. Physical laboratories are the traditional laboratories occupying real space, have real equipment and require expertise to function effectively. Virtual laboratories have become complementary and in some cases, alternative to physical laboratories. They are used in the "anytime, anyplace, on-line learning" world of engineering education. They are also increasingly being used to supplement traditional learning. This paper reviews the merits and demerits of virtual laboratories in engineering education.

Keywords: Virtual Laboratories, Open and Distance Learning (ODL), Engineering Education.

1. INTRODUCTION

Laboratories are important component of engineering and engineering education. With the rapid development of Information Technology (IT) or recently well-known as the Information and Communication Technologies (ICT), virtual laboratories are used as an alternative or a supplement to the physical or real laboratories. Virtual laboratories have been developed in a number of engineering and scientific disciplines using a variety of simulation techniques. The virtues or virtual laboratories are not equal in terms of creation, development and maintenance costs. The educational benefits are also not the same.

This paper is organized as follows. Section 2 reviews virtual laboratory definition. In Section 3 and 4, we review the merits and demerits. Finally, Section 5 summarizes the paper and discusses possible areas for further research.

2. DEFINITION OF VIRTUAL LABORATORIES

Virtual laboratories are defined here as one type of interactive multimedia objects. Interactive multimedia objects are composed of various formats that include text, hypertext, sound, images, animations, video and graphics. Virtual laboratories are available in three formats as below:

- a) Virtual laboratories with 2-D simulation,
- b) Virtual laboratories with 3-D simulation, and
- c) Sensor-actuated and remotely-controlled virtual laboratories.

The following sections will analyze the merits and demerits of the use of virtual labs in engineering education.

3. MERITS

a) Logistics

- The logistics of tailoring a real laboratory particularly when dealing with large number of users or students is really a big concern. The requirements for space, the instrumentation, the human support is very high. The virtual laboratories have least concern even when dealing with large number of students.

b) Low Cost

- The cost to set-up a virtual laboratory is relatively very low compared to real laboratory. Unlike real laboratories, replacements are not required for virtual laboratories due to malfunction, damage etc.
- Operating and maintenance costs are very low compared to real laboratories. Unlike real laboratories, virtual laboratory does not require daily maintenance and expertise to function effectively.

c) Open and Distance Learning (ODL)

- Historically and until recently, lectures, tutorials and laboratories are delivered through conventional ways of delivering engineering education. With the development of ICT, engineering education via

ODL becoming a reality. Laboratories are one of the principle ways that engineering students learn how to apply theory. So, virtual laboratories, like any other ODL tool, it makes no difference whether a student is in a campus (in traditional university) or at home (in virtual university). It gives unlimited opportunities to ODL students to conduct laboratory experiments without going to physical laboratories.

d) Safety

- Virtual laboratories have no safety concerns compared to real laboratories. For example, it is very useful when experiments involving equipment may cause harm to human being, i.e. lasers, nuclear tests, toxic chemicals analyzers, etc.

e) Educational Benefits

Learning Methodology, Pedagogy and User Friendly

- Some students find they are not easily able to understand some concepts in a normal lab class. However, studies have found that it is easier to learn difficult concepts through the virtual labs.
- Students are more active in learning in a virtual environment than in a real lab class. This is because virtual lab provides a user-friendly interface and easy to understand concepts. Experiments can easily be repeated and there are no inconveniences in failing experiments.

Complex Problems

- Virtual labs take away some of the ordinary tasks like number crunching. As a result, they are likely to do more problems or investigate further. For example, the structural designer lab quickly solves a large set of equation for every new design. A student would lose interest immediately if he had to do the calculations by himself like in a real lab.

Instructor Benefits

- Instructors or lecturers benefits from the virtual labs too. It is somewhat easier to change experimental parameters once the experiment is set-up. The students can do more detailed experiments by changing different variables. That can be time consuming for both instructor and students in a real lab.

- The learning of student can be monitored continuously. Instructors can keep a record of how students perform as they progress through it. If many students get a particular element wrong, the instructor can change his/her style or improve the content of the lecture.

4. DEMERITS

a) Skill Requirement

- Students are required to have prior knowledge on PC, WWW and internet. Without this, they may not fully utilize the features and options provided in a virtual lab.

b) Hardware and Networking Requirement

- In principle, PC's with multimedia capabilities are required for virtual labs.
- Some virtual labs may require servers with high speed broadband internet connection. This is not possible for users from remote areas who depend on low speed internet connection or even without any internet connections.

c) Virtual Lab Software

- The virtual lab software's continuously changing along with ICT developments. Some virtual lab software may become obsolete soon and may require periodical updates and new investments.
- Not all laboratories are available in virtual labs form. This can be a problem for ODL students.
- The cost to develop a virtual lab is also can be very expensive depending on the experiment type and complexity.
- Licensing and copyright issues, i.e., pirated software and legal implications to the user/institution.

d) Ethics and Professionalism

- Data manipulation by users to obtain a specific outcome or result that favours them may affect the engineering ethics and professionalism.

e) Realism

- Virtual lab with 2-D simulation is less realistic compared to the 3-D simulation. Not all virtual labs are available in 3-D simulation.
- Most agree that a virtual lab will never replace a hands-on-lab due to less realism.
- No matter how sophisticated virtual lab technology becomes, a virtual lab will never be able to replace the unexpected characteristics of a real lab, i.e., the weird noise, the random error, the faulty machinery, etc.

5. CONCLUSION

Virtual laboratories offer some advantages in engineering education and can supplement real laboratories. Virtual laboratories can be an alternative to real laboratories when such laboratories are not available because of space or funds or equipment malfunction. Most importantly, engineering distance education cannot be fully realized without virtual laboratories technology and support. For virtual laboratories to have a positive impact, the simulation must be as close to real simulation as possible and be firmly grounded in rich technology.

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