

The Sustainability of the use of Virtual Laboratories: A Literature Review

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Abstract:- This paper presents a discussion on the sustainability of virtual laboratories in education. It is a literature review paper which outlined the importance of virtual laboratories as well as the challenges to the sustainability of virtual laboratories. Ways of enhancing sustainability such as resource maintenance and maximum usage of virtual laboratories were explained. When proper design, development and implementation of virtual laboratories are well-coordinated, these can help the learning process.

Keywords:- Sustainability, Virtual, Laboratory, e-learning.

I. INTRODUCTION

Since the end of the 18th century, the world has seen remarkable significant changes in the delivery of education. This has been influenced by the ever-expanding influence of technology. One such development is the adoption of online learning across different learning contexts, which saw the science and engineering field making use of virtual laboratories. Laboratory activities play a vital role in complementing the learning process in engineering and other fields. This kind of change resulted in schools, teachers, and students increasingly adopting e-learning technologies that allow teachers to deliver instruction interactively, share resources seamlessly, and facilitate student collaboration and interaction (Elaish et al., 2019; Garcia et al., 2018). Despite the visible challenges which come with technology in its implementation, the usefulness of online learning has long been acknowledged by the education community across the world (Barrot, 2020, 2021; Cavanaugh et al., 2009; Kebritchi et al., 2017; Tallent-Runnels et al., 2006; Wallace, 2003). Even though e-learning has been in existence before the COVID 10 pandemic, the uncertainty brought by it has escalated the need to understand and sustain the method. In fact, education technologies are now used to design, deliver and manage learning and knowledge sharing at any time, any pace and any place (Gedera, 2014) making education accessible with little mobility. The use of e-learning has enabled more students and teachers to interact outside the four walls of the traditional classroom. Indeed, e-learning is so far the most effective way of constructing knowledge and enhancing teaching and learning in the absence of face-

to-face interaction induced by Covid 19. The use of Virtual Laboratories (VL) is fast replacing the traditional (physical) laboratories in supporting the learning process in most institutions. A virtual laboratory is one of the methods used in e-learning and this has proved to be effective as traditional physical laboratories in terms of imparting comparable knowledge and skills to learners. Azad (2007) noted the high success rate of virtual laboratories in institutions of education and training. However, the worry is on the sustainability of these virtual laboratories across the world.

II. DEFINING A VIRTUAL LABORATORY

This is the creation of an interactive environment for creating and conducting simulated experiments (Salmeron-Manzano and Manzano-Aguguar, 2018). It can also be defined as set-up comprising computer hardware and the required software which is capable of simulating the activities that can be performed in a traditional physical laboratory where students can meet the face-to-face with the facilitator. However, like in a physical laboratory, the purpose is to impart comparable knowledge and skills to learners. It is also the creation of an environment where students interact with an experiment or activity which is intrinsically remote from them.

III. IMPORTANCE OF VIRTUAL LABORATORIES IN EDUCATION

Today's curricula of most educational institutions, especially higher education institutions are based on the new technologies and of late are coming on board the virtual laboratories (Salmeron-Manzono and Manzono-Aguguar, 2018). It is inevitable that some areas like engineering and technology require the performance and analysis of experiments even in this era where face-to-face education is declining due to health crises such as Covid 19. This is where students are expected to experiment in a laboratory to confirm the theoretical models. Experiments also help students to have a practical orientation. While it is prudent to talk of both traditional laboratories (real laboratories) and simulation laboratories, this paper gives priority to the simulation laboratories, specifically virtual laboratories as shown in fig 1 below:

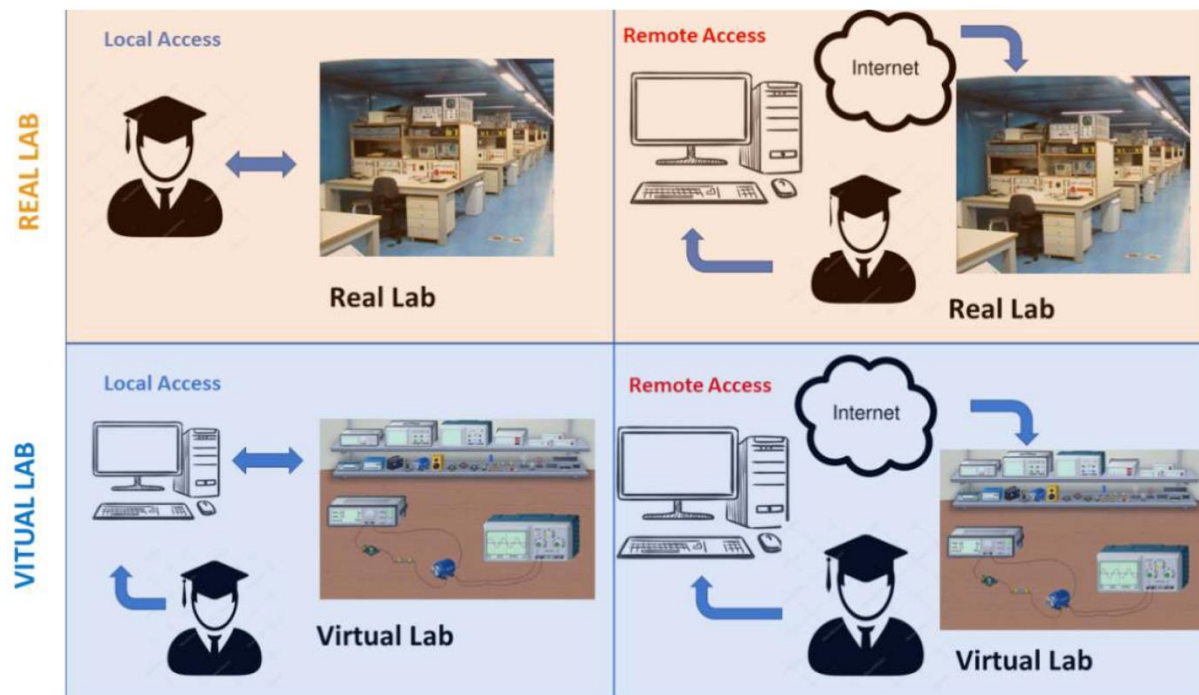


Fig. 1: Types of working environments for laboratories

Source: Salmeron-Manzono and Manzono-Augiliano (2018)

IV. ADVANTAGES AND DISADVANTAGES OF VIRTUAL LABORATORIES

A. Advantages of Virtual laboratories

Among the main advantages of the virtual laboratories that make them more sustainable are:

- Can be either local or remote access,
- The experiences are closer to a larger number of students,
- No limit to the number of opportunities,
- Experiencing without risk,
- No equipment can be damaged while learning how to use them,
- No laboratory equipment was used,
- The place and time of the practices are made more flexible,
- A self-study mode can be considered where the input variables can be modified by the student.

B. Disadvantages of Virtual Laboratories

And, among the main drawbacks, are the following:

- They do not provide the same enriching experience as a direct practice,
- The student may behave like a viewer,
- Laboratory reality can be distorted (if a proper simulation is not available), and
- Loss of teamwork skill due to excessive individualism on the part of the students.

V. CHALLENGES IN THE SUSTAINABILITY OF VIRTUAL LABORATORIES

Virtual laboratories have proved to save the same purpose as physical laboratories in conceptualising practical concepts (Corter et al, 2007). Reading from the advantages

of virtual laboratories stated above, it can be deduced that if well designed and developed, virtual laboratories may even become more valuable to traditional laboratories (Lang et al, 2007). The sustainability of VL should be considered from its design and development stages. The following are some of the topical challenges hindering the sustenance of Virtual laboratories:

A. Technological changes

Like any other e-learning method, virtual laboratories require software and hardware setup. This type of challenge is experienced in two ways, that is, software and hardware changes. Generally, there is a rapid change in software tools which requires a system to adapt to the new software regularly in order to move with time, or else it becomes outdated. It should be understood that the virtual laboratory works with the server computer which executes experiments. However, the results of the experiment are communicated to the students' client computer which should be installed with the matching software for efficient and effective communication. More so, software updating is required in meeting the speed requirements.

The hardware of the system is another area which requires regular repair, changing and updating to avoid obsolescence. It is also important to note that as new or upgraded software is installed, the hardware also demands renovation to absorb new software's functioning, for example, to cope with the speed. These changes are coupled with financial cost which might be a challenge for most educational and training institutions.

B. Societal support

Societal support for the sustenance of e-learning is very important. If the use of technology is received negatively

by society, it is likely to fail. Toddlers get an orientation on information communication technology (ICT) tools (eg computers) as early as before their formal school days. This literally points that children start familiarising themselves with computers at home during their early days. As they go to school for formal education, they would have already been motivated in the use of ICT equipment. This makes it easier to implement virtual laboratories. In fact, society (home environment) does pave way for children to be motivated in the use of e-learning tools. Educators therefore, find it easier to keep the learners within the ICT environment as there is no effort to be put into re-shaping the learners (Muratoglu and Ozman, 2006).

C. Educators' attitude

Educators are important stakeholders who have a stake in determining the sustainability of virtual laboratories. It is believed that older generations of educators are less proactive in the use of ICT tools, as such; e-learning might be a problem. They would try to avoid the use of new technologies and sometimes are referred to as computer phobia (Selwyn, 1997). Those who avoid the use of virtual laboratories give the reason for lack of control over the activity and also fear of being replaced by the computer. Heinich et al (1993) noted that the computer does not replace educators instead, replaces their traditional roles and assigns them to new roles of being creative managers and facilitators as computers become a new information source. Those educators who fail to see the benefit of the computer always wish to avoid them (Fidan, 2008). Teachers and educators should realise the highest benefit from the use of VL systems in order to help sustain their use.

VI. MEASURES TO SUSTAIN VIRTUAL LABORATORIES

A. Maintenance of resources

This calls for periodic maintenance of both hardware and software components of the virtual laboratory system. Like any other ICT system, virtual Laboratories require corrective and timely actions against faults to keep their reliability. Failure to properly maintain the system will cause interruptions in the services which can negatively affect its sustainability. Software is another component of the virtual laboratory system which requires attention. These problems which are likely can be avoided by applying a defensive approach from the development phase of the system. Moreso, the virtual laboratory system should be regularly checked for conformance to safety constraints.

B. Multi-user system

The virtual laboratory system involves extensive resources during the design and development phases. It is very expensive to set and maintain the system. The high costs could be offset if the system is made use of multi-users. The virtual laboratory system should be designed and developed to serve various users. Generally, virtual laboratories need to serve a wide range of clients which include undergraduate students, graduates, engineers and even technicians. The flexibility of a virtual laboratory enhances its sustainability. In fact, the virtual laboratory functionality should be enriched for sustainability of purpose.

VII. CONCLUSION

Laboratories activities and of virtual laboratories are very important in education as they supplement the learning process. Virtual laboratory as technology-based system has a number of challenges which sometimes hinder its sustenance. These challenges include technological changes, societal support, and educators' attitudes. It is important that the issue of sustenance of the system should be incorporated from the design and development phases. Maintenance of resources and wide use of the virtual laboratory system are some of the measures which can enhance sustainability of virtual laboratories.

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