Virtual Labs

Learning Objectives:

At the end of this lecture, the students will be able to understand

1. Definition
2. Introduction
3. Need of Virtual Labs
4. Beneficiaries of Virtual Labs
5. Benefits of Virtual Labs
6. Weaknesses of Virtual Labs
7. Available Virtual Labs

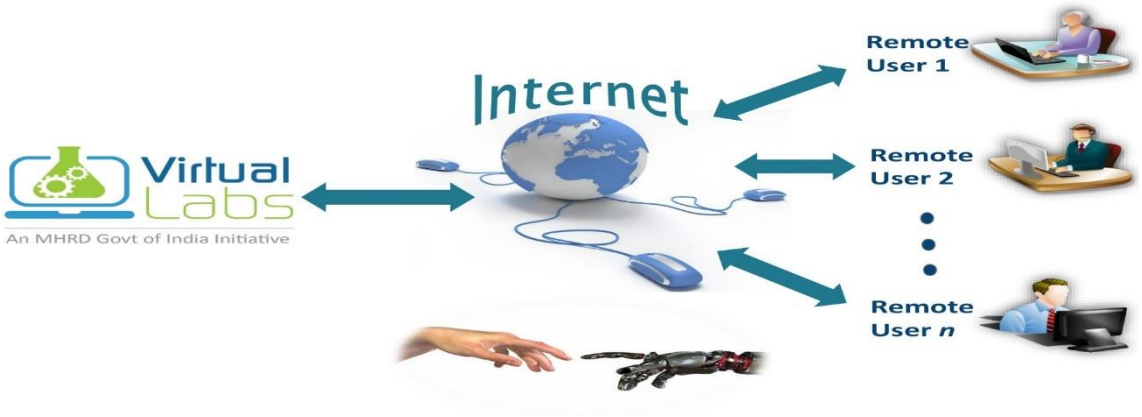
1. Definition:

Virtual labs[8] are simulated learning environments that allow students to complete laboratory experiments online and explore concepts and theories without stepping into a physical science lab.

Virtual Labs or Online Labs (OLABS) enabled schools to perform various experiments and activities without physical labs or limits. It proved to be efficient educational technology and gained popularity among teachers and students during the Covid 19 pandemic.

Virtual Labs[1] is an initiative of Ministry of Education (MoE), Government of India under the aegis of National Mission on Education through Information and Communication Technology (NMEICT).

The project aims to provide remote access to Laboratories in various disciplines of Science and Engineering for students at all levels from undergraduate to research.[2]



Students can try out lab techniques for the first time and become more familiar with advanced lab equipment that might otherwise be inaccessible.

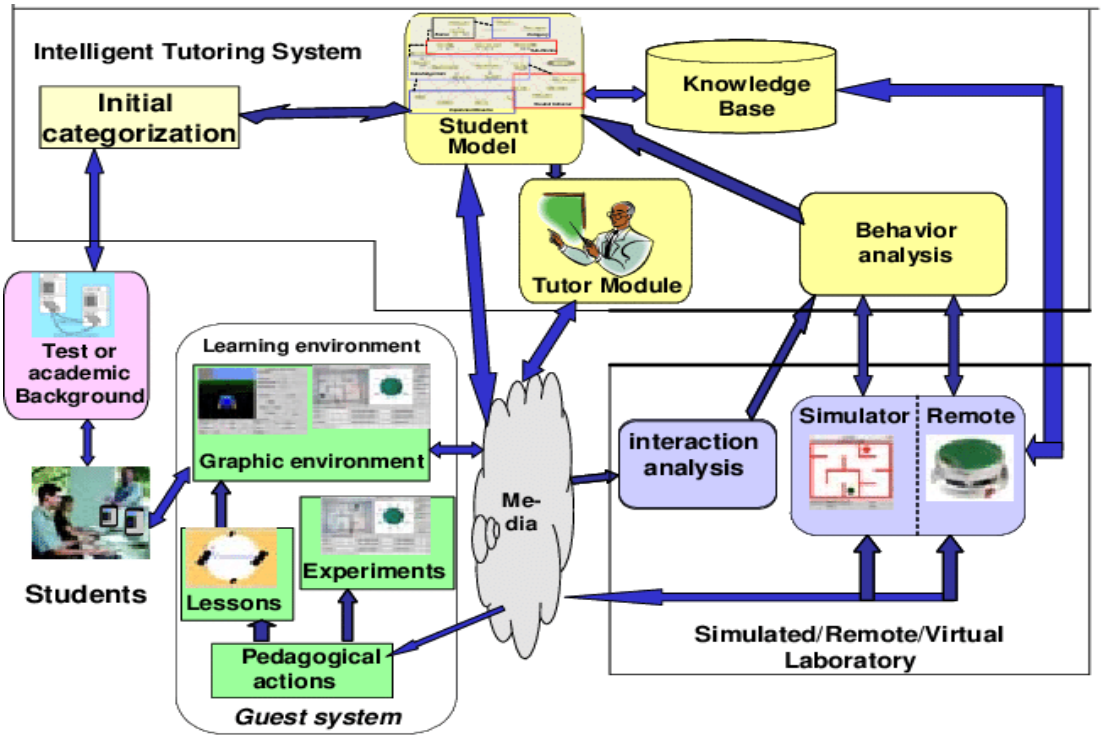
Through animations, students can explore life science at a molecular level and look inside the machines they are operating.

Virtual lab software creates opportunities for alternative access to science education.

2. Introduction

Virtual Labs have been designed to provide remote access to labs in various disciplines of Science and Engineering. These Virtual Labs cater to students at the undergraduate level, postgraduate level as well as to research scholars. Virtual Labs enable the students to learn at their own pace and enthuse them to conduct experiments. Virtual Labs also provide a complete learning management system where the students can avail various tools for learning, including additional web resources, video lectures, animated demonstration, and self-evaluation. Virtual Labs can be used to complement physical labs.

Architecture of Virtual Lab[10]:



The project is coordinated by IIT Delhi and there are a total of 11 participating institutes in the consortium. IIT Delhi, IIT Bombay, IIT Kanpur, IIT Kharagpur, IIT Roorkee, IIT Guwahati, IIT Kharagpur, IIIT Hyderabad), Amrita Vishwa Vidyapeetham Coimbatore, Dayalbagh Educational Institute Agra, NITK Surathkal, and College of Engineering Pune are the institutions participating in the project.

The Project covers Computer Science & Engineering, Electronics & Communications, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Biotechnology and Biomedical Engineering, Civil Engineering, Physical Sciences, and Chemical Sciences broad areas of engineering.

Virtual Labs do not require any additional infrastructural setup for conducting experiments at user premises. One computer terminal with broadband Internet connectivity is all that is needed to perform the experiments remotely.

Virtual labs[9] are considered one of the most important techniques of e-learning, as they enable both teachers and students to achieve the educational process' goals. This is done

by facilitating the application of the practical side of the curriculum at any time and place, and without any form of restrictions.

And technology applications in the field of education have varied widely during the past few years. And development rates have accelerated in the field of e-learning in response to the digital transformation that we are witnessing in various areas of life now.

Virtual labs have saved a lot of time and effort. Also they removed many obstacles that were faced by both student and teacher to conduct experiments. As they facilitated the conducting of experiments outside the real labs.

3. Need of Virtual labs

Challenge #1: Limited lab access

Many high school and university students cannot get their hands on lab equipment. Whether it is due to social distancing during the pandemic or the high cost of specialized equipment, many schools are not able to teach important lab techniques.

Challenge #2: Limited time in the lab

Very few students have unlimited time to spend in a lab due to safety and cost reasons. At the same time, many experiments are time-consuming, and lots of time can be wasted on waiting for experiments to complete. Additionally, students sometimes feel the pressure of finishing experiments quickly. As a consequence, students' attention can shift from learning the experiment to just getting it done.

Challenge #3: Low student motivation and engagement

Classrooms with a passive learning environment significantly reduce students' motivation to learn and engage in the content of their course. In addition, students tend to become disengaged if they cannot see or understand the real-world relevance of what they are learning. Down the road, you risk ending up with unmotivated students, some of whom eventually drop out.

Challenge #4: Teaching complex topics

Without active visual tools, it can be incredibly hard to explain to students the complexities of certain scientific concepts.

Challenge #5: Making mistakes in high risk environments

Safety is of the utmost importance when working in a lab. But students tend to be unprepared for the experiments they are engaging in, and unaware of what can happen if something really goes wrong, putting them at risk when working in a real lab.

Challenge #6: Ethics

For experiments that test or dissect parts of animals, there are many questions involving ethics that teachers must consider. Because it is unethical for students to experiment with certain animals, students rarely get the chance to learn about these experiments

Challenge #7: Unprepared students and knowledge gaps

With little-to-no lab access, many students don't feel prepared and confident enough to carry out experiments in a lab. At the same time, students often have different starting points, leaving knowledge gaps between students.

4. Beneficiaries of Virtual labs

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.
- Access to quality simulation-based labs as a complementary facility to those colleges that already have labs.
- A complete Learning Management System around these labs.
- Teacher-training and skill-set augmentation through workshops and on-site training.
- 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.

5. Benefits of Virtual Labs[8]

- **As a visual aid to teach complex concepts**

Virtual labs can be used to help you as a teacher explain complex theoretical concepts. A visual, immersive experience can make it easier for students to get to grips with complex concepts, such as the composition of DNA.

- **To refresh students' knowledge before teaching new material**

Virtual Labs can be used as a tool to help students reflect on previously covered topics. Using the simulations as a prerequisite to new material can help eliminate the time and resources that may otherwise be used to ensure the students are up-to-date on their learning.

- **As a pre-lab exercise**

Virtual Labs can be used as an exercise to teach students the safety measures, techniques, and procedures that will be required before they undertake a real-life lab experiment. This can be particularly useful if the experiment is complex or new to the students.

- **To provide lab work to courses with no existing lab component**

For students in courses that lack a lab component due to time restraints, a lack of resources, or for other reasons, using Virtual Labs can majorly enhance their learning.

- **To facilitate online learning**

Since the outbreak of the pandemic, teachers have relied on Virtual Labs to support students who are learning at home. Virtual Labs quizzes help teachers to record and track students' academic progress so they can initiate individual coaching when needed. Assessments can also contribute to an overall class participation grade.

- **As a post-lab exercise**

Virtual labs can be used following a lab experiment to help students reflect upon and analyse their results. This can be helpful to ensure that students internalise the tools and skills that they have learned.

6. Weaknesses to use virtual labs[9]

- They require computer devices with high specifications in order to simulate the exact phenomena with full details and create a three-dimensional virtual lab.
- They require professional programmers with strong skills in different programming languages. They also require a team of experts in the scientific material, teachers, and experts in psychology.
- One of the negative effects of Virtual Labs is that it reduces the direct interaction between students and each other, and between students and teachers, given that the communication between them is electronically most of the time.

7. Available Virtual Labs[2][3]:

S.No	Name of the Department	Name of the Virtual Lab	Description of the Virtual Lab	Weblink of the Virtual Lab
1.	Multi Disciplinary	Vlabs	Virtual Labs for Multi Disciplinary.It is an initiative of Ministry of Education (MoE), Government of India under the aegis of National Mission on Education through Information and Communication Technology (NMEICT)	https://www.vlab.co.in
2	Computer Science	SimSE	An educational software engineering simulation environment	https://www.ics.uci.edu/~emilyo/SimSE/index.html
3	Biology	Biology Simulations	Biology Simulations.	https://www.biologysimulations.com/
4	Biology	Case It!	Molecular biology simulations.	https://www.caseitproject.org/
5	Bio-Technology	DNA from the Beginning	An animated primer of 75 experiments that made modern genetics.	http://www.dnaftb.org/##
6.	Physics	Algodoo	Physics Simulations	http://www.algodoo.com/

S.No	Name of the Department	Name of the Virtual Lab	Description of the Virtual Lab	Weblink of the Virtual Lab
7.	Chemistry	Chem1 Virtual Textbook	Reference text for general chemistry.	http://www.chem1.com/acad/webtext/virtualtextbook.html
8	Chemistry	Chemix	Chemix is an online editor for drawing science lab diagrams.	https://chemix.org/
9	Physics	HTML5 Physics Simulations	Manipulate systems and experiment with climate change, motion, forces, gravity, momentum, energy, and rotation.	http://physics.bu.edu/~duffy/HTML5/index.html
10	Multi Disciplinary	LabXchange	Curates and creates world-class digital labs, delivered on a free, online platform that lets you integrate your learning and research experiences.	https://www.labxchange.org/explore
11	Multi Disciplinary	PhET	Interactive simulations for physics, chemistry, mathematics, biology, and earth science.	https://phet.colorado.edu/
12	Electronics	LogicSim	design and simulate digital logic circuits with logic gates like AND, OR, FlipFlop, etc.	http://www.tetzl.de/java_logic_simulator.html#overview

8. Conclusion

The virtual labs are one of the most important applications of e-learning. As it provides a virtual learning and teaching environment that aims to develop practical skills of the students. And since they are available through the Internet, the student can conduct many experiments without being restricted to a specific location or specific times as It is the case when using real laboratories.

9. References:

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8. https://www.labster.com/the-complete-guide-to-virtual-labs/
9. https://blog.praxilabs.com/2020/04/22/all-you-need-to-know-about-virtual-labs/
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