Development of Virtual Labs for Remote Experiential Learning

Ms.N.Sai Prathyusha[1], Mr.R.Gopi Raju[2], Ms.Ch.Mani[3], Asso.Prof.Dr.Y.Syamala[4], Asst.Prof.K.SreeLakshmi[5]

[1]B.tech. Final year, Department of Electronics and Communication Engineering, Seshadri Rao Engineering College, Andhra Pradesh, India

[2]B.tech. Final year, Department of Electronics and Communication Engineering, Seshadri Rao Engineering College, Andhra Pradesh, India

[3]B.tech. Final year, Department of Electronics and Communication Engineering, Seshadri Rao Engineering College, Andhra Pradesh, India

[4]Asso.Prof. Department of Electronics and Communication Engineering, Seshadri Rao Engineering College, Andhra Pradesh, India

[5]Asst.Prof. Department of Electronics and Communication Engineering, Seshadri Rao Engineering College, Andhra Pradesh, India

ABSTRACT

With digitalization, learning and knowledge sharing are leaping towards web-based practices. Ongoing pandemic has overemphasized the necessity of an online seamless learning experience; without requiring specific architecture or system configuration for practical learning. Hence, it is essential to have a robust learning environment that caters to students all the time. With the disruption caused by the pandemic, learners and educators have experienced and understood the importance of integrating technologies that help in students' education. With the correct use of technology, learners can be catered to their needs more efficiently than prevalent practices. Virtual labs are simulated learning environments that allow students to complete lab experiments online, explore concepts without any physical lab equipment, and obtain conclusions to fulfill a learning objective. Virtual labs are easy to use and available on the internet 24X7. These Virtual labs are designed and developed using web technologies like HTML, CSS, JavaScript for Graphical User Interface development, whereas canvas and SVG are used for simulator development. With the development of these laboratories, an online resource for accessing the experiments can be made approachable with a tailor-made user experience at any time. The implementation of web-hosted Virtual labs promoted inquisitiveness in the learners. The ready availability of tools for scientific study encourages learners and researchers to work on practical applications improving understanding and retention of concepts. Learning by experience on simulator followed by self-assessment is beneficial in awakening the self-reflection and innovation in learners.

Keywords - Virtual laboratory[1], online learning, Web-based technologies, Simulator[2], Innovation.

1. INTRODUCTION

Remote laboratories are a popular innovation in engineering education. These facilitate students to equip with practical knowledge without the physical presence of an individual. The advantage is that one can have 24/7 access to the virtual laboratories which helps in teaching and learning process in a way that there are practical assignments and every student can practice and even carry out additional experiments[3]. Due to the pandemic situation, it has become difficult to have real-time practice of technical skills. Hence, in these present situations, it is important to shift to a conventional teaching and learning pattern. In addition to this, it is predominant to ensure that the method leads to the required learning outcomes for the students. Virtual laboratories are designed to overcome this issue thereby providing quality learning for every student. The core spirit of engineering is to find the pain points and come up with solutions to these problems. Thus it is necessary to impart theoretical knowledge hand in hand with practical applications. To realize this, Virtual laboratories are developed to give round-the-clock access to students and researchers to conduct experiments over the internet remotely. The hands-on training through virtual laboratories proves to be phenomenal in imparting the scientific principles as well as the resulting practical phenomena wherever they are situated. This novel "learning by doing" or experiential learning promotes curiosity and inquisitiveness among students and helps them understand the concepts better. These virtual labs are web-based labs that illustrate experiments that require costly equipment and are difficult to assemble. The provided features facilitate efficient practical learning. In the provided labs, we worked on providing an easy-to-use interface for the users to understand the working of the circuit as well as designed the circuit elements as near to real life as possible so that the user can get a near-to-real-life experience[3]. The virtual labs not only help students understand the theoretical concepts better, but they also promote Self-paced learning which is very important. This practice of self-learning makes them not rely on external resources or any other references for guidance; they learn to research and know more about the topics on their own. Learning from various resources also helps them arrive at a greater understanding of the concept not confining to one particular notion, they get a complete and whole idea of the topic. The

self-assessment is also provided in the pre-test and post-test features thus giving the students an opportunity to test the knowledge they gained and the topics that are yet to be practiced more and need to be relearnt or revised. We briefly explained every experiment in the form of theory and procedure. The provided platform is also so easy to use such that navigation from one tab to another and accessing the information while doing Virtual laboratory for Analog Electronics simulations is hassle-free and well documented through instructions on how to use. Many students prefer computer-assisted teaching to conventional classroom teaching. This also proves how by leveraging the technology and using virtual tools to teach we can bring about a better learning experience for the students and a better teaching experience for the teachers as well.

2. LITERATURE SURVEY

The current system is manual and requires a facilitator to be present. As a result, the file contains all of the information about the student, courses, and instructors. Faculty have many files for various purposes, such as a separate file for student information, attendance, reports, and so on[4]. Students use multiple notes for different subjects, and they occasionally forget something during lectures. This Virtual Classroom System is accessible at any time and without restriction, allowing us to use it 24 hours a day[5]. Although lab application in students' learning is extremely significant in science education, It has various limitations and issues-particularly in underdeveloped countries. Because India is a developing country, it faces the same issues as the rest of the world. The following are some of the major issues that have been encountered: Laboratory activities are costly in terms of carrying out experiments and setting up equipment. It takes a long time to plan and put into action. In overcrowded courses, it can be difficult to monitor students' performance during activities. The teacher is unable to execute a simple lab activity due to a lack of lab or equipment, or improper lab settings. They also overcome the potential risks that can be seen in real-life lab situations[6]. For example, a hazardous experiment for human health is created as a simulation on the computer so that students can view the experiment design, perform the experiment on the computer, and observe the results. Simulations have advantages over undertaking unsafe, difficult, or impossible tests.
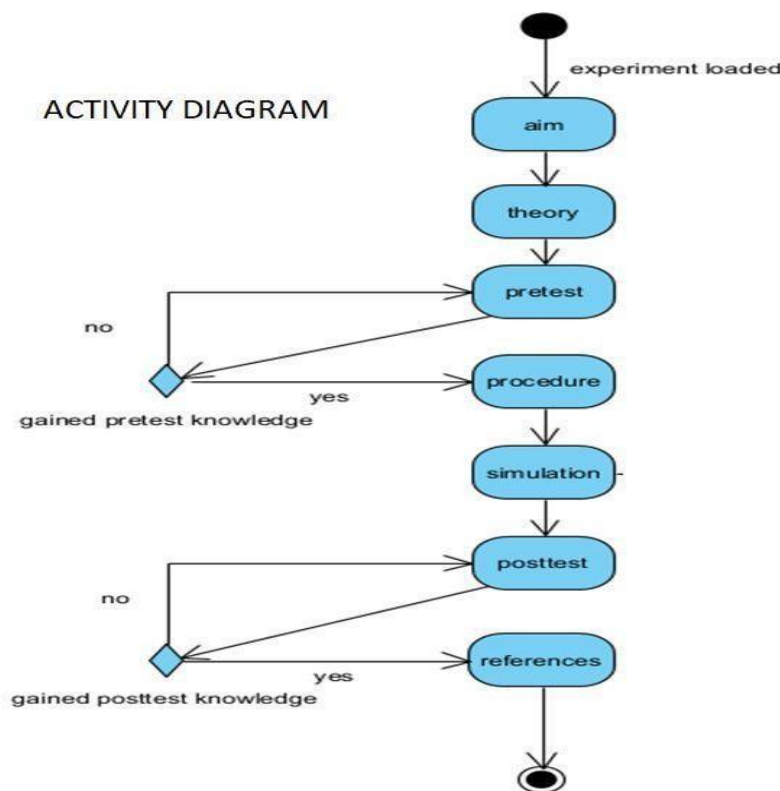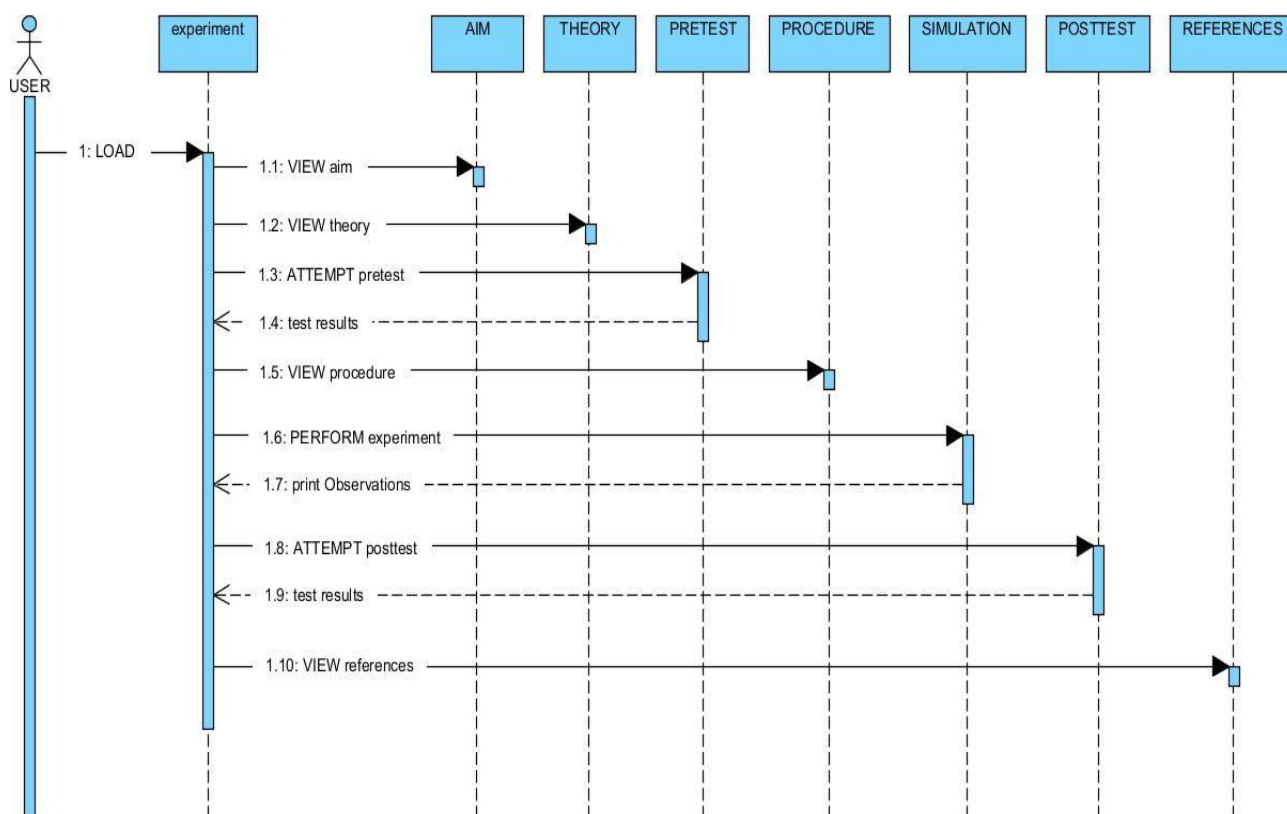

Fig: USE CASE DIAGRAM

Fig: Sequence Diagram

2.1 **Comparative study of Conventional lab setup and a Virtual lab setup:**

In a virtual lab, GUIs are used to implement several interactive experiments, giving students practical experience on important theoretical aspects fulfilling the learning goals. The main objective of a Virtual Lab is to engage the students in related theoretical topics, starting with very fundamental concepts and progressively and hierarchically building up their knowledge to the level of current state-of-the-art approaches. These Virtual Labs are intended to be of use both to tutors giving in-class demonstrations and to students studying at home and performing laboratory practicals. In-class demonstrations using the interactive GUIs can complement lectures, offering an immediate visual interpretation of the concepts discussed. The Virtual Lab is accompanied by comprehensive documentation that provides an essential summary of the theoretical concepts behind each experiment, along with instructions that describe the structure and functionality of each GUI, and provides a set of exercises/quizzes for self-assessments.

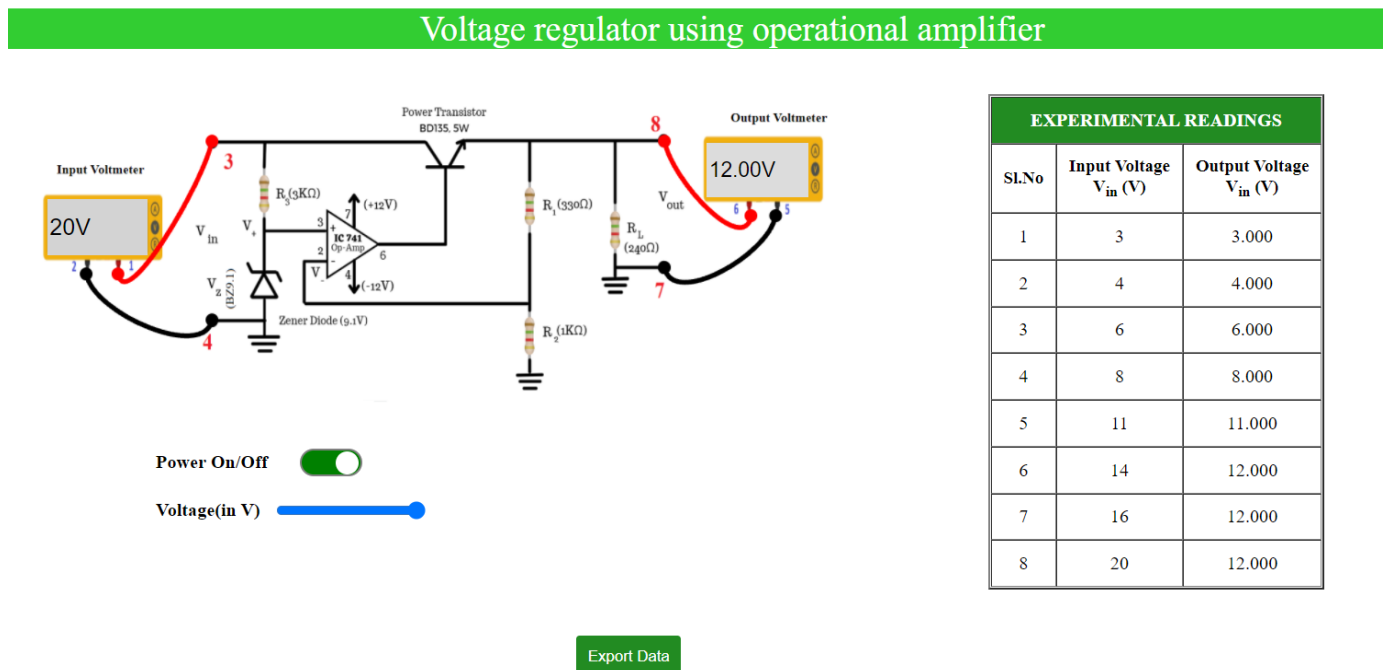| S.No	Conventional lab setup	Virtual lab setup
1.	Large numbers of students taught by a restricted number of educators	Well planned and articulated modules to give detailed instructions
2.	The understanding gap between theoretical and Practical learning	Integration of practical simulators with theoretical resources results in greater comprehension.
3.	Complex theories that need imagination can be harder to comprehend when taught on a board	Visualization makes it easier to teach complex theories and experiments and boosts creativity

4.	The lab resources and equipment are limited and it is not possible to facilitate all the students at a time	Each student is provided access to the virtual lab and can avail it whenever and wherever they want.
5.	Not always up-to-date also it is hard to keep up with rapidly changing technology	Up-to-date and easy to upgrade depending on the new technological advancements
6.	Not easy to procure and maintain sophisticated lab equipment to inaugurate a new lab	The development and setting up of a new lab is less tiresome than in conventional teaching practices.

2.2 Advantages:

- Easy to use.
- Provides efficient practical learning.
- No need to have any additional resources. Just the availability of a laptop/smartphone/ tab and internet are enough.
- Free of cost.
- Open-source.
- Portable.
- Availability of hands-on exercises and simulators may create zeal in learners to learn something new.
- As it provides practical examples, it reduces the learning time enabling learners to learn in less time.
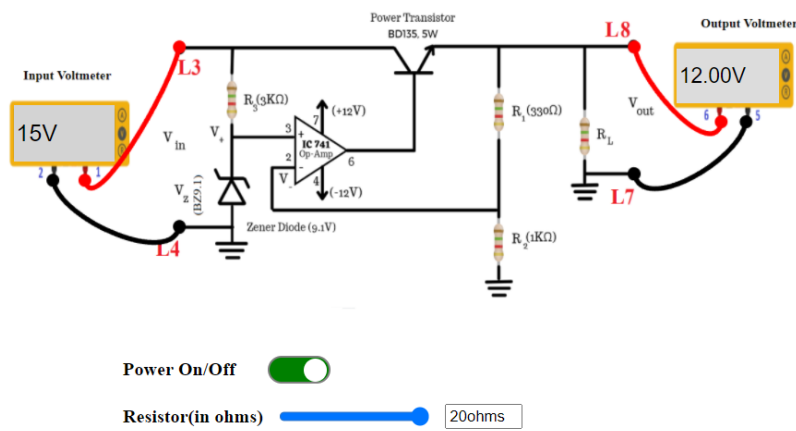
2.3 Results:

The following are the images of the User Interface of simulations that are available in the Virtual labs for remote experiential learning The instructions are well documented and wires are color graded to provide ease of understanding. The readings can be easily obtained from the tables and can be noted down for further learning.

Voltage regulator using operational amplifier

EXPERIMENTAL READINGS		
Sl.No	Input Voltage V_{in} (V)	Output Voltage V_{in} (V)
1	3	3.000
2	4	4.000
3	6	6.000
4	8	8.000
5	11	11.000
6	14	12.000
7	16	12.000
8	20	12.000

Fig. Simulation of Voltage Regulator using operational amplifier - Line regulation

EXPERIMENTAL READINGS		
Sl.No	Input Voltage V_{in} (V)	Output Voltage V_{in} (V)
1	3	3.000
2	4	4.000
3	7	7.000
4	9	9.000
5	12	12.000
6	15	12.000
7	18	12.000
8	20	12.000

Power On/Off

Resistor(in ohms) 20ohms

Export Data

Fig. Simulation of Voltage Regulator using operational amplifier - Load regulation

EXPERIMENTAL READINGS		
Sl.No	Input Voltage V_{in} (V)	Output Voltage V_{in} (V)
1	3	3.000
2	4	4.000
3	6	6.000
4	8	8.000
5	11	11.000
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5	12	12.000
6	15	12.000
7	18	12.000
8	20	12.000

(a) Results of Line Regulation   (b) Results of Load Regulation

2.4 Future Scope:

The Virtual laboratory currently aligns with the syllabus of selected universities and covers most of the use cases that are encountered while working with the particular domain and their applications, this can be extended and a greater number of experiments can be included which may include using of these electronic circuits in industrial, scientific and medical applications.

3. CONCLUSION:

Virtual laboratories for remote experiential learning have many advantages over the conventional system of knowledge sharing practiced and help students gain practical knowledge from the comfort of their homes. This also serves as a great tool for students to revise their experiments at home to prepare for exams. These Virtual labs also help in imparting practical knowledge to students undergoing academics online who are not equipped with enough resources to get a practical understanding of the theoretical topics taught. These virtual labs also help in modernizing and making the learning experience more student-centric. These easy-to-access and custom-made Virtual labs act as tools to spike the curiosity of the student community and also permit them to follow at their own pace at their own time even outside the lab hours.

References

[1] Liu, D., Valdiviezo-Díaz, P., Riofrio, G., Sun, Y., & Barba, R. (2015). Integration of Virtual Labs into Science E-learning. Procedia Computer Science, 75, 95-102. doi:10.1016/j.procs.2015.12.224

[2] Rajendran, Lavanya & Veilumuthu, Ramachandran & RAMACHANDRAN,. (2010). A study on the effectiveness of virtual lab in E-learning. International Journal on Computer Science and Engineering.

[3] R. Bose, "Virtual Labs Project: A Paradigm Shift in Internet-Based Remote Experimentation," in IEEE Access, vol. 1, pp. 718-725, 2013, DOI: 10.1109/ACCESS.2013.2286202.

[4] Chen, Xuemin & Song, Gangbing & Zhang, Yongpeng. (2010). Virtual and Remote Laboratory Development: A Review. 10.1061/41096(366)368.

[5] Sri, D. & Srividya, M. & Yarlagadda, Syamala. (2020). Remote Laboratory for Implementation of Various Applications Using Linear and Digital ICs. 10.1007/978-3- 030-23162-0_18

[6] The Effect of the Virtual Laboratory on Students' Achievement and Attitude in Chemistry, Cengiz Tuysuz Usak Üniversitesi, Yenitepe, 2001

[7] J. Anthony Vento, "Application of Labview In Higher Education Laboratories," Proceedings of Frontiers In Education Conference 1998, pp. 444-447

[8] Stalling, William(2006). Computer Organization and Architecture: Designing for performance 7th ed. Pearson Prentice Hall,p 13.