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Low Cost Digital Trainer Experimentation Platform –A Case study

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Abstract — Improvement in Technology has imparted huge changes in the field of Education, to be precise it has revolutionized the Traditional classes to Online Learning platforms, similarly this work portrays the necessity in improvising the experimental laboratory courses that requires high cost hardware, experts in the Hardware operation, Software usage and its understanding in performing a simple digital circuit experiment. Upright there is a need for a low cost system and user friendly platform for the learners that provides an opening to learn the practical courses at any place. The above statement is fulfilled by creating an Indigenous Application that works on a GUI platform that can be interfaced with any system on a ready to go installation setup. Experimental verification of the working platform and its advantages over the traditional system are distinct with the feedback from the users. A comparison study of Traditional lab experiments, open source online experiment and Blended laboratory experiments are conducted and its outcomes are analyzed. The obtained results shows that Blended learning is 1.5% and 0.5% better than the Traditional and Online learning experience respectively.

Keywords: Traditional Laboratory, Open source online Laboratory, Hybrid Laboratory, GUI Platform, low cost Trainer Kit, Arduino, Multiplatform app, Digital IC

***JEET Category*—Practice**

I. INTRODUCTION

Traditionally laboratory experiments are conducted through high cost machines which need to be upgraded every year towards the change in the technology that costs huge amounts for software renewal, Maintenance of the machine and machine operator. Due to the pandemic and the need for interactive sessions in laboratories these high cost machines fail to provide adequate knowledge with respect to the technology. Sometimes those machines are an era old that are not in the industrial operations which leads to inadequate resources. Yixuan Dong et.al [1] have explained the need for Internet + Education in the post pandemic era and their perspective on online education platforms for providing multidimensional thinking among students. Barbara B. Lockee [2] have insisted on the need for change in the education system from traditional classrooms to virtual learning platforms by providing flexible learning environments. Darling-Hammond, L. et al [3] have created a framework for transforming the learning environment by closing the gap between the opportunities and achievement. Stein & Graham [4] in their books explained the various methods of blended learning for creating effective learning experience by providing a streamlined approach. Conrad & Openo [5] have detailed the various assessment processes and strategies for online learning and their effectiveness in imparting knowledge. E.Irigoyen, E.Larzabal et. al. [6] detailed the process of including a low cost [7] learning platform in their university syllabus for providing better learning in control engineering education.

From the above studies conducted by various researchers, there is a need for low cost devices for conducting laboratory experiments that can provide better learning outcomes through Virtual platforms and Hands on Experiments. This study conducts Hardware based experiments, Software based experiments and Hardware, software blended experiments in Digital Electronics Laboratory course by providing low cost Experimental setups for con- ducting experiments and open source online software for visualizing the results to user friendly learning experience. A comparative study is conducted among the three experimental methods and assessed to find the optimal method for conducting Lab experiments.

II. CASE STUDY

For doing digital Electronics experiments, a lot of virtual and hardware based kits are available in the market. Using simulation software does not provide hands -on experience and there is a lack in psychomotor development skills for the students. Some of the platforms used for doing digital electronics experiments is given below.

A. *Case 1: Digital Trainer Kit*

This is the most basic experimentation setup for practicing simple digital circuits. Different types of trainer kits are available in the market which are proprietary and require experienced instructors to assist students use the kit for doing simple experiments. A sample trainer kit is shown in the Fig. 1 which contains bread board area, IC pin out area which has easy access to IC pins, power supply area, clock pulse generator and Digital input switches and output LED Area.

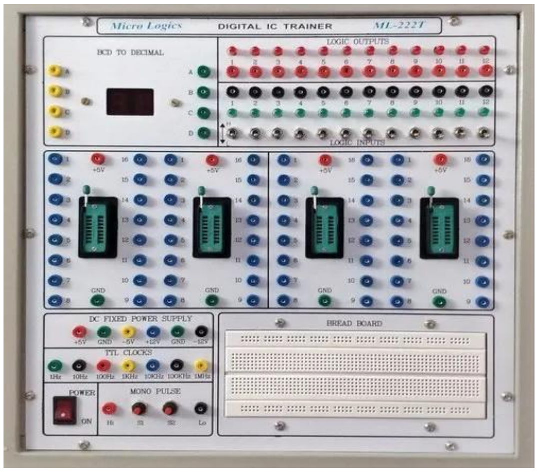

Fig. 1. Hardware only digital Trainer Kit

For our laboratory experiments, a proprietary hardware and software is used for doing the experiments. It requires a high maintenance with experienced instructor and a pc to operate the ELVIS kit as shown in Fig. 2. It works under sophisticated serial protocol to control hardware. Due to high cost and high maintenance, students are not able to purchase this hardware and software for doing DIY experiments.

Fig. 2. Multipurpose hardware used for Digital Experimentation

B. *Case 2: Virtual Learning Platform*

Due to covid19, access to hardware cannot be made, in order to provide some hands on experience, Tinkercad circuits which uses the IC based simulation for doing experiments is shown in Fig. 3. Students have done Experiments during online classes using this platform for conducting experiments.

The Advantages of this virtual simulation is, it doesn't require any sophisticated hardware or software to do experiments. It requires internet connection, email account and a PC/laptop for doing experiments.
The Drawbacks are no exposure to real hardware and wiring in breadboard for students. Easy to simulate without any experienced supervision and also sharing of circuit between students during online classes exams.

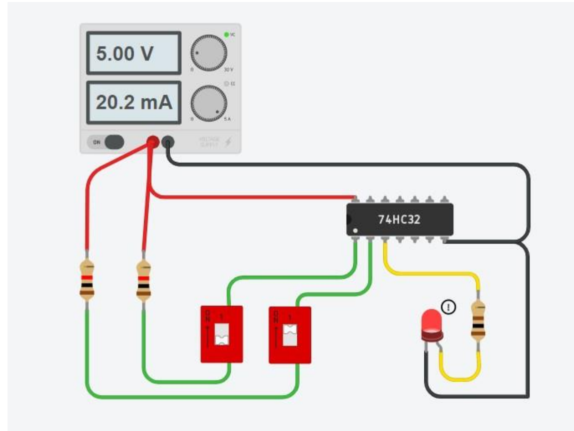

Fig. 3. IC based simulation platform (Autodesk Tinkercad)

C. *Case 3: Low cost Hybrid Learning Platform*

Because of the versatility and ease of use of the virtual environment, it was planned to use a blended model for conducting digital experiments by developing a low cost digital trainer that can be used both in lab and in a Do it Yourself (DIY) home lab after covid19. In this paper, a complete Open source hardware and software trainer platform is proposed.

1) *Functional Decomposition*

The functional decomposition of our learning platform is given in Fig. 4. It consists of hardware and software part. In the hardware part Open Source Hardware arduino as an interface hardware is used that provides digital inputs to the experimental circuits.

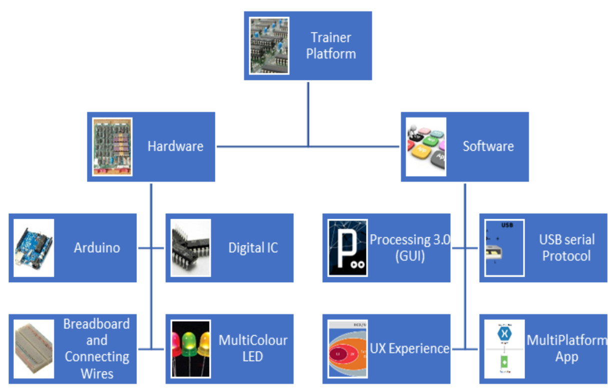

Fig. 4. Functional Decomposition of Low Cost Hybrid Learning Platform

The Arduino was controlled by indigenously developed software that uses java for programming and is platform independent, so that it can be used on any platform. For control a custom serial protocol has been developed for interfacing and control over USB as shown in Fig. 5.

Fig. 5. Conceptual Design of Hardware

In Fig. 6, the complete setup of the trainer platform that is used for doing experiment is shown. Since the software is platform independent it can be used in PC or Raspberry pi.

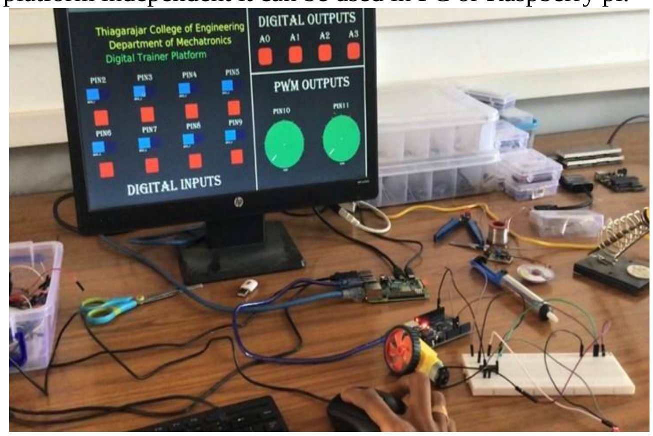

Fig. 6. Trainer Platform developed using open source Hardware and Software

2) System Operation

For performing Digital Electronics experiments in undergraduate learning levels, the maximum number of inputs required for a digital circuits are 8 and the maximum number of outputs required are 4. So Arduino UNO has been chosen as an interfacing device, for the communication between the software and hardware – The Firmata protocol is used [12]. Firmata is an USB communication protocol that are developed to control the hardware using software through USB port.

Similarly the processing software has a Firmata library [11] which provides communication over USB to control arduino. Using both the libraries, a Graphical User Interface (GUI) has been developed for conducting Digital Experiments as shown in Figure.6. The GUI contains 8 digital inputs and 4 digital outputs for experiments. Pulse Width Modulation (PWM) outputs can also be used to control various devices.

III. Experimental Description

The Digital Electronics laboratory is conducted for III semester Mechatronics students group. There are 12 experiments, in which 3 different batch students conducted lab experiments in three different platforms namely Digital Trainer Platform, Virtual Laboratory Platform/Online Learning Platform and Blended Learning Platform. Students are given circuit diagrams, manuals before every experiment and also advised to learn the basics of the experiments, by which the students will know the experiments to be conducted in the next laboratory. These Lab experiments are conducted by two groups with 12 batches each containing 3 students in a batch. Before entering the lab, students are given precautionary information in handling the equipment and safety in conducting experiments. In traditional classroom, the experiments are conducted through sophisticated hardware and software requiring psychomotor skills to conduct lab experiments. The virtual platform requires cognitive skill to deliver the experiments. Blended platform requires both the psychomotor skill and cognitive skill to conduct experiments.

IV. Assessment for Case Studies

For all the three case studies, there are two course outcomes for conducting a Digital Electronics laboratory. The lab experiments are conducted one by one and the performance of the students are noted in each laboratory by assessing the results in the experiments conducted. Their outputs are verified by measuring the overall performance by the 67 students in a classroom. The course outcomes in all the three modes of learning in conducting the lab experiments by the three batches are given in Fig. 7.

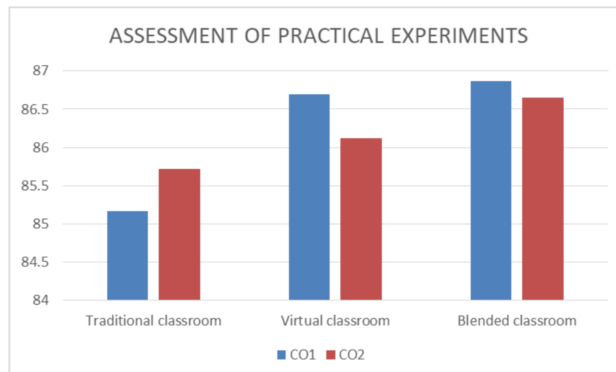

Fig. 7. Assessment of Practical Experiments with Course Outcomes

Table 1 shows the performance of the teaching method for course outcomes (CO) achieved in the three modes of study with the percentage of marks. In which the traditional classroom have underperformed when compared with the results of the 67 students in each case of online and blended learning classroom. Blended learning have achieved learning outcomes by 1.5% better than Traditional classroom and 0.5% better than the Virtual classroom.

TABLE I
TEACHING METHOD PERFORMANCE

Teaching Method	Academic year	No. of Students	Percentage of Marks secured	
			CO1	CO2
Traditional	2019-20	67	85.165	85.715
Virtual	2020-21	67	86.7	86.115
Blended	2021-22	67	86.87	86.655

V. Result and Conclusion

From the above three different modes of conducting lab experiments, Blended mode has given better results than the traditional and online platform because it has provided both the hands-on training and open source software based learning which in turn lead to better outcomes in learning by the students. Also with respect to the traditional hardware and software based learning, Blended classroom platform requires internet connectivity and low cost hardware tools to conduct experiments at their time of preference. Blended Classrooms do not require highly skilled people to operate the hardware and software when compared to traditional classrooms. It is identical that Blended lab environment has provided better learning outcomes than traditional and online platforms.

VI. Future Works

This work can be further implemented in the Analog circuit's laboratory which has high cost software and hardware systems. This type of low cost learner device can be provided for any electronics laboratory which needs more technical support, low cost hardware and user friendly systems.

References

Yixuan Dong, B., & Bo Shao (2022). Status and Development of Online Education Platforms in the Post- epidemic Era. *Procedia Computer Science*. 202, 55–60.

Lockee, B. B. (2021). Online education in the post-COVID era. Nature Electronics. 4, 5–6.

Darling-Hammond. (2020). *Restarting and Reinventing School: Learning in the Time of COVID and Beyond*. Learning Policy Institute.

Stein, J., & Graham, C. (2020). *Essentials for Blended Learning*, Routledge - Taylor and Francis Group.

Conrad, D., & Openo, J. (2018). *Assessment Strategies for Online Learning: Engagement and Authenticity*. Athabasca Univ. Press.

Irigoyen. E, & Larzabal. E. (2013). Low-cost platforms used in Control Education: An educational case study. *IFAC Proceedings Volumes,* 46 (17), 256-261.

Josey, S., & Alvi, P. A. (2018). Effectiveness of 'Low Cost Experiments' in Assimilating Fundamentals of Physics. *Inter- national Journal of Mechanical Engineering and Technology*. 9(11), 860–866.

https://processing.org/ - open source GUI platform
https://www.arduino.cc/ - open source hardware platform
https://www.tinkercad.com/ - online virtual simulator
https://github.com/firmata/processing - Firmata Library for processing
https://docs.arduino.cc/hacking/software/FirmataLibrary - Standard Firmata for arduino.