Abstract- with new revolutions in every sphere of life, the world is evolving much faster than we can gauge. Technological advancements are happening at a lightning speed and humans are racing not only cope with these developments but to remain humane even when everything around them compels them to become mechanical. Education has also seen a drastic change, specifically in the pedagogy. New concepts like andragogy and constructivism has emerged. To make learning effective and to imbibe what you learn, it is imperative that whatever we learn, we learn thoroughly and not mechanically just to attain some grades. Keeping holistic and conceptual learning in mind, the concept of e-learning emerged. The traditional approach of class room learning is enhanced with these teaching aids. Three dimensional visualization is not possible in classroom but through animated videos and clippings and the utilization of technological resources teaching has now reached to a different level altogether. These papers is about one effective and efficient tool we have developed that aims to redefine re-engineer and revolutionize the entire process of laboratory learning in schools and colleges in India. Our application The ‘E-know-V’ Labs – our applications aims to fill in the gaps between the maximum potential of laboratory learning and present traditional learning. It will enable teachers to make it easy for students to visualize various experimental concepts which due to reasons of cost, technical incapability is difficult to be performed in lab like experiments with gold. Students will thoroughly imbibe the learning. Our application can be regarded as falling into the category of pervasive computing because it can be deployed on desktops, laptops, mobiles and tablets and can be accessed from anywhere. Using the concept of networks and rich computer graphics we want to provide a rich tool to leverage laboratory learning.

Keywords- gamification, virtual lab, andragogy, constructivism, MOOC

I. INTRODUCTION

Laboratories are important components of education to make students to gain experience. No scientific education is complete without having laboratory aid to complement the learning. Many researchers in science education admitted that laboratory studies increase students’ interest and abilities for the science subjects. To imbibe and truly understand what we have learnt in theory we need a practical sessions in addition. Every Indian school and college teaching Physics, Chemistry and Biology have provisions for laboratory to facilitate the learning of these subjects in its truest sense. This practice has been there for a long time. The normal practice is during the term, the students are given the facility to perform and practice the experiment and also evaluated. Generally there is a series of formulae and some theoretical concept backing every experiment. After performing of experiments, students are required to write a journal or file, stating the theory, tabulating data, applying the formulae, doing calculations, plotting graphs and finally arriving at inferences. It has been seen that there are many short comings with this process and the main motive of learning the practical application of certain theories and concepts is not met.

Most students do these experiments mechanically. They know the expected answer, they know the set of formulae and they back calculate or manipulate calculations to finally arrive at the correct answer. Many students are not aware of the concepts involved, they just do what is to be done and strive to get the permissible answer. This obtaining of marks is not the sole aim of laboratory education. The objective is to imbibe the knowledge and understand the concepts thoroughly.

Also, there are many short comings associated with the traditional laboratory pedagogy. In carrying out experiments and arranging with equipment, the laboratory activities are expensive. For planning and application, it is much time consuming. Checking students’ performance during the activities can be difficult in over-crowded classes. Lack of laboratory or equipment, or insufficient lab conditions which limits the teacher to perform a simple lab activity. Scarce and expensive materials are never experimented with. Every Institution has very few rooms allotted to labs and since those are shared by the entire institution, once a lab is conducted very rarely students get a chance to repeat the experiments a number of times to enhance their learning. Generally labs are a once a week affair. There are so many possibilities and dimensions of an experiment which is dangerous or may be fatal if performed in actual laboratory but performance of those experiment and knowing the results is also of immense value.

II. EXISTING VIRTUAL LABS AND THEIR CLASSIFICATION

There are various kinds of virtual labs presently existing in the world and each one of them has gained immense popularity for their respective advantages over the other systems. All these labs fall in the category of MOOC-(Massive Online Open
Courses). Different virtual labs use different technologies for the lab simulation purpose. The main purpose of each of the virtual labs remains same— they allow students to simulate experiments that may require expensive or dangerous hardware and materials from the safety of their desktop and laptops. Recently virtual laboratories have gained press coverage (news.bbc.co.uk, 2001) where they are described as “bring(ing) science to life”.

Virtual labs are also categorized into two main sectors depending on the way they gain knowledge. The first one is fact based wherein limited set of facts is inserted by the programmer; this is the way that the majority of systems currently work. The second one, base their knowledge around a piece of far reaching piece of theory, this permitting a greater range of experiments to be performed. Some of the famous virtual science laboratories are The Universal Campus: An Open Virtual Three Dimensional World For Research And Education, Pierre Baldi and Crista Lopes, April 2012. Development of a Virtual Laboratory System for Science Education, University of Hanover, The virtual lab, University of Virginia.

Along with these there are various kinds of approaches used in the development of such virtual learning environment. Gamification is one of them. In short, gamification is the use of game play mechanics for non-game applications.

Some virtual laboratories use COVASE; COVASE is a toolkit to develop educational visualization and simulation environments for students, researchers, and tutors in the natural and engineering sciences in a rapid way. CoVASE supports visualization, a basic use of dialogue as a means to find common properties in a series of observations, virtual desktops that connect to remote computers to run external applications and also sessions can be recorded.

The main hindrance in these virtual labs becoming popular is that most of them fall under the category of luxury education and is not at all affordable by the majority of the students worldwide. Also most other virtual labs are designed exclusively for particular foreign universities and have restricted access.

In India also this concept has gained attention and the Government has come up with its own virtual lab project— Virtual Lab (India). It is a project initiated by the Ministry of Human Resource and Development, Government Of India. This project aims to provide remote access to laboratories in various disciplines of science and engineering for various levels of undergraduate and research. It aims to develop complete Learning Management System.

Seven IIT’s (Delhi, Bombay, Kanpur, Kharagpur, Madras, Roorkee and Guwahati), IIIT Hyderabad, Amrita University, Dayalbagh University, NIT Karnataka, and College of Engineering, Pune, are the institutions participating in the project. What our product aims to do is to make these virtual labs and simulations available to schools and pre-university level colleges as well as undergraduate colleges. It can be used to enhance the existing laboratory education in schools and colleges. It makes the assessment process clear and easy for both students and teachers. We provide a rich user interface to make the product appear attractive to the students. Our product is also cost-effective and very simple to use.

### III. PROPOSED SYSTEM

#### A. Overview

A new approach to revolutionize, re-engineer and remodel the existing laboratory education in India. Our product is named E-Know V Labs. ‘E’ stands for e-learning since the entire system is a kind of e-learning wherein we have developed a virtual lab software distributed on a network based on client-server (student-teacher) architecture where server can set specifications for clients. ‘Know’ stands for knowledge or know-how that is the main objective of our application to increase the knowledge of students by enabling them to perform experiments built using rich computer graphics and explore such dimensions in the experiment which in reality is impossible due to costly resources and man power and other technical issues. The ‘V’ implies the virtuality of the experiments. E-know V labs come with a lot of advantages: To provide a suitable environment to extend, improve, integrate, refine and assist the experimentation process of various subjects.

- To increase the effectiveness of scientific experiments
- Easy to use
- Can provide cutaway views that let you see aspects of an object that would be invisible in the real artifact, as well as visualization tools that can provide many different perspectives.
- Does not fall into the category of luxury education.
- Labs are designed keeping in mind the Indian Education System

#### B. Process Explanation

There is a server (teacher) and many clients (students). The clients connect to the server. Once connected they are requested to login. After login the server chooses experiments for the client either on broadcast basis or in a randomized fashion. The teacher sets the parameter for the experiment and sends it to the student. The experiment chosen by the server launches on the client’s side. The student can view the demonstration of the experiment or start to perform the experiment. While performing the...
experiment, the student has to tabulate the data in the table provided, calculate the parameter required, plot the graph and send back the final result to the teacher. The teacher verifies the answer and with a simple algorithm that we have used calculates the error percentage and send back the marks and comments to the teacher. At any point of time, the teacher can monitor the student by taking screenshots of what is being done at the client side.

Whenever a client connects to the server, an icon of the server is created in the homepage of the teacher along with the USN of the student. On clicking the icon, the student details like name, USN, experiment name are displayed. Student details along with marks are stored in flat files.

Once the experiment launches, the student can easily proceed to performing the experiments.

For e.g. the teacher can select the simple pendulum experiment from the list of experiments in his homepage. He can select constraints like radius of the bob and number of swings. The student opens that experiment and performs it along with these constraints and sends back the value of ‘g’ for the teacher to evaluate.

C. Building The Lab

This virtual lab has been developed using a gaming engine called Unity 3D. Our experiments are all based on the concept of gamification that is using game like approach for non-gaming applications. Below is the architecture diagram of our application.

The entire code is written in C Sharp(C#) with adhering to Camel Case Coding Standards. We have used built in classes in Unity that have been used for the inter-process communication between the client and the server.

There are several protocols available to achieve inter-process communication, RPC (Remote Procedure Call) is among them. RPC protocol uses message passing technique to communicate between client and server. We have designed virtual science lab using unity software in c# language.

Initially a c# script is created using monobehaviour class. Unity Engine and System. Collections packages are included in our script. One or more classes extending from monobehaviour class are created. Following are some of the functions included in unity application software.

Void Start () {}:- which runs only once at the beginning.
Void Update () {}:- it is executed frequently.
Rect windowRect = new Rect(initial_width, initial_height, Screen.width, Screen.height);
windowRect = GUI.Window(0, windowRect, Function, “page heading”);
Teacher runs the application software in the active mode and broadcasts its IP address and port number using the Network.peerType.Server property.

The network class is at the heart of the network implementation and provides the core functions. This class configures the network interface and all the network parameters. It is used to set up a server or connect to one and have a row of helper functions to help with those tasks. The Network class has various
static variables like connections, is Client, incoming Password, is Server, log Level, player, proxyIP, proxy Port, time; various static functions like Connect, Destroy, Get Last Ping, Allocate View ID, Initialize Server; various messages like On Connected To Server , On Failed To Connect, On Server Initialized to deal with all the interconnectivity between server and client. Both the developing and the deploying environment for the application is same. For server & client machine the hardware requirements are Intel Core or higher processor with 256 MB or more graphic card memory, 1 GB or more RAM and minimum 1 GB hard disk space.The operating system requirements are Windows 7 or higher versions of Windows. Other software tools required was Adobe Photoshop to design the various graphical user interfaces. Student requests for connection establishment through USN using Network.peerType.Connect (). The teacher on receiving request message responds the student by sending an acknowledgment. Teacher fetches all the necessary information about the student and assigns the experiment to be performed and sets all the parameters. Student performs the experiment set by the teacher according to the parameters assigned by the teacher. Student can take the screenshots and send them to the teacher so that the teacher can come to know the current status of the student. Screenshots are taken in the form of texture initially and are later converted to bytes by reading pixel by pixel and are sent to the teacher. At the teacher side the texture is extracted from the bytes and saved in the form of .png images by creating separate folders for each student. Student enters the observations in the tabular column and plots the graph if needed. Student calculates the final result using the calculator provided and submits the result to the teacher. Teacher evaluates the results and sends the standard result and error percentage with necessary comments. All the above messages are exchanged between client and server using networkView.RPC property.

IV. RESULTS

After developing the virtual science lab application – ‘E-know V Labs’ we have tested it manually for the various test cases for successful and exceptional and error cases.

<table>
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<tr>
<th>Net ID</th>
<th>Input Description</th>
<th>Expected Output</th>
<th>Actual Output</th>
</tr>
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<tbody>
<tr>
<td>4</td>
<td>4. Out going RPC message between student and the teacher</td>
<td>Messages sent by the student to the teacher are delivered within 100 milliseconds.</td>
<td></td>
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</tbody>
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<table>
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<th>Net ID</th>
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<th>Expected Output</th>
<th>Actual Output</th>
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<tbody>
<tr>
<td>5</td>
<td>5. Refracting Time Period</td>
<td>Refracting time should not go down below 20 milliseconds</td>
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<th>Net ID</th>
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<th>Actual Output</th>
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<tbody>
<tr>
<td>6</td>
<td>6. Protocol Flexibility</td>
<td>Protocol must work with any 6.3.1 and all other higher versions.</td>
<td></td>
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Fig. 6 A set of test cases for E-know V Labs

![Fig. 6 A set of test cases for E-know V Labs](image)

It has been found that the time required to set the parameters is less than 10 seconds 80% of the times, Application screen loaded spontaneously when the application is launched within 5 seconds 90% of the times, Submitting the answers would be less than 30 seconds 90% of the times, all the application threads are killed right after clicking the quit button, all the threads and services related to a certain intent are terminated right after the intent switch.

As per the security requirements, only authenticated users have access to this application and modification of parameters done only by the teacher (administrator) and the teacher is entitled with the privileges of setting parameters and verifying answers.

Learning of the application is very easy as we are thinking of providing a user manual to users. Also we have designed the graphical user interface in such a way that it increases the overall usability of the application, an important concern for any product.

The deployment of this application in a school or college will definitely enhance the existing lab learning methodology there. An attractive GUI will definitely attract more and more students to use the application. Gamification of the experiments makes it easier for the students to perform the experiments. Three dimensional views and flexible experimentation definitely deepens, extends the knowledge of students and exposes them to such imaginations that were limited by lack of equipments and resources like experimenting with gold. Approximately 10 schools are ready to buy the product. BVB College of Engineering and Technology itself is ready to deploy our application.
in their laboratories to enhance the existing mode of laboratory education.

CONCLUSION

Virtual Laboratories have the added benefit that in the case of an error the worst that can happen is a program crash, where as errors in a real laboratory can lead on great expense, both in terms of man power, and repairs (J C Waller, N Foster2000). This leads to a greater confidence in the student, as they have been able to experiment and test ideas without the worry of breaking apparatus, "The first time they were faced with any instrument, they were more worried about damaging it or making a mistake, than leaning how to use it. The Virtual science Lab application ‘E-know V Labs’ will totally revolutionise, remodel and re-engineer the present and traditional laboratory education scenario in India. Though we have just included pre-university level and science degree level and first year engineering labs in our product, we aim to extend it the post graduate and higher research levels in India. The experiments are totally modeled keeping in mind the Indian syllabus at various educational levels. Presently we are going to deploy this on school or college desktops. Later as a part of future scope we can install them on tablets or phablets with similar configurations and provide remote access to labs and students can practice lab assignments sitting at home from their tablets.

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