Simulating Electronic Circuits on Android Device using Virtual Bread Board

Zeeshan Ali
National University of Modern Languages
Islamabad, Pakistan.
Z33shan4li@gmail.com,

Abstract-**For more than forty years, the breadboard had been a valuable instrument for fundamental electronic experiments. In any case, even for an experienced user, a complicated wiring work could be a bad dream amid the procedure of experiment. It requires time for wiring, as well as a non-consistent error may emerge at whatever point there is a free contact between jump wire and the electrical terminals of the breadboard. That is to state, once in a while, you can't guarantee that the affirmed circuit works accurately even after a cautious wiring work. In this paper, focused on digital circuits, we examine the effect of substituting a simulation for real breadboard equipment. We have designed android based virtual breadboard, which will be used for building circuits and to test the output of the circuit, it replaces the faulty equipment and also it eases the building of circuit and replaces the complex wiring mechanism and also it enables the user to identified the faulty circuit before PowerOn the circuit which saves the user from non-logical error. During field study we find out that simulations are more productive and cost effective and also there is less chance of doing logical errors also it removes the doubt of faulty equipment.**

I. Introduction

As education and technology combine, these open doors for educating and learning grow considerably more. However, the exceptionally fast rate of progress in the fields of innovation postures unique issues for scholastic foundations, particularly for the designing orders. There is obviously a nonstop need to redesign and increase the substance of address courses to keep pace with this change, however it is in the territory of designing training and test work where real concerns emerge. The focal issue still continues as before; accommodating understudies important and pertinent down to earth encounters while being restricted by exceptionally limited assets in the arrangement of research facility equipment and framework.

One answer for this issue is to utilize virtual based strategies to interface the understudies with the physical world, with reasonable front end configuration to give expanding refinement and expanded adaptability. Numerous scholarly courses that show building subjects have as of now started fusing virtual based instructive apparatuses for understudy utilize, either in the addresses or in the lab rehearses or both. Moreover, data and experience sharing are turning out to be progressively basic to instructive establishments and in addition to rehearsing engineers, for the most part determined by the headway in virtual innovation and the Internet.

Microcomputers have been utilized to enlarge substantial scale addresses [1], to advance little gathering/singular understudy work [2] and most zones in the middle. In the laboratory, PCs have filled in as minor increments to gather or show information, as a method for altering research facility encounter, [3] or as entire virtual universes in which understudies implant themselves [4] [5]. Sherry Turkle questions the thought processes and support for utilization of PCs in education. [6]

"Why ought to fifteen year olds empty virtual chemicals into virtual measuring beakers? Why ought to eighteen year olds do virtual experiments in virtual material science research centers? The response to these inquiries is frequently: on the grounds that the recreations are less costly."

Electronic simulations may increase student access to laboratory experience, since they are not compelled to one particular time and place. Quality simulations may improve planning and furthermore diminish cost by limiting the utilization of costly hardware. They could likewise spare time, as the hardware would not should be set up and afterward dismantled and set away at every session. Connecting the reproduction to instructional exercises and reference data, and giving an inherent drilling capacity could likewise limit the prerequisite for a full-time lab associate. The standard mediums individuals use to design and build electronics remains generally the same: the breadboard, the protoboard, and the printed circuit board (PCB). The breadboard gives a press-fit network to quick connections and disconnections for testing circuit and alteration. Since these circuits are constructed utilizing just press-fit associations, breadboards are incredible for quick prototyping yet very delicate as conclusive items.

Here, we look at the viability of completely replacing traditional hardware with android based simulations i.e. with Android Virtual Breadboard (A.V.B). Given the constraints (e.g., extensive cost) of conventional labs), we investigate whether it is possible to achieve the conceptual learning gains and mastery of mechanical skills associated with real equipment by instead working with android simulations.

Android Virtual Breadboard (A.V.B) is an application that enables a user to design circuits on virtual breadboard by using android device. This application provides digital parts including, integrated circuits, wires, switches, and light emitting diodes (LED's) for designing circuits, testing and experimenting them. Virtual wires are used to make connection between different points on virtual breadboard. Virtual Integrated Circuits (IC's) are used to implement logics. Virtual switches are used to provide input to the circuit and virtual light emitting diodes (LED's) are used to display output. The application allows user to name the inputs in order to provide better understanding to the user. The application supports two formats in which the output can be displayed. These formats are truth tables and circuit diagrams. This application is used for learning purpose and provides user-friendly interface.

We extend prior work by examining the following research questions:

- Can simulations be used productively?
- Will students learn the same concepts and will they learn them as well?
- Will students develop an understanding of using real equipment by working with simulations?

Our outcomes indicate that appropriately designed simulations used in the right contexts can be more effective educational tools than real laboratory equipment, both in creating student facility with genuine equipment and at fostering student conceptual understanding.

II. Related Work

Given the growing research in non-traditional approaches to building electronics, many researchers are now looking at incorporating more off-the-shelf and existing components. DidacTronic, a development and prototyping kit for digital and analog electronic circuits [7]. From a craft perspective, squishy circuits [8] is a circuitry sculpting technique using conductive modelling clay and Perner-Wilson [9] systematically studied a variety of traditional craft practices, to see how existing materials and techniques could be applied to circuit building. Mellis et. al. [9] used off-the-shelf microcontrollers, traditional craft materials, conductive ink and open hardware and software tools to create an approach to circuit building that is friendly to new circuit builders by relying on familiar craft techniques. Jie Qi et. al. introduces a method in which circuits are hand-made on ordinary paper substrates, connected with conductive foil tape and off-the-shelf circuit components with the aim of supporting the durability, scalability, and accessibility needs of novice and expert circuit builders alike. [10]

III. Scope of System

The scope of this application is to automate the manual execution of IC's on a breadboard. The primary extent of this application is to give a simple way to the client for executing logic gates by using IC's. This application gives a simple method for learning. Need of this application is as indicated by instructive request that empowers the client to execute logics by using virtual IC's, virtual breadboard and virtual wires. This framework is created for all android phone clients related with the field of electronics. The prompt clients of this application are students, educators and experts.

IV. Pilot Study

We conducted pilot study with 10 participants. The purpose of the study was to find out the bugs within the application as well as that how much the system is user friendly.
Android tablets with AVB were presented to participants and they explore system for about half an hour and then review was given.
According to review more zoom should be introduced to be more precise on the area of touch on screen. Also according to their review the front end colors are dull and it gives boring look to the user so later on new color was introduced within application to increase the attractiveness.

V. System Working

Android Virtual Breadboard (AVB) is designed for the students of electronics, it provides user ability to make circuits virtually. Seven IC's are supported by user as shown in fig1:

S#	COMPONENT	SPECIFICATION
1	AND GATE	IC 7408
2	OR GATE	IC 7432
3	NOT GATE	IC 7404
4	NAND GATE 2I/P	IC 7400
5	NOR GATE	IC 7402
6	X-OR GATE	IC 7486
7	NAND GATE 3I/P	IC 7410

Figure 1: Supported IC's

On application load, Main menu appears and if user is new to application he/she has an option to open the help page to get the guidance how application will work and how the connections can be created. After getting the guidance user may now proceed to load new breadboard, after loading the screen will appear with blank breadboard. There are certain buttons on the top of breadboard, Back, IC, Snap, Reset, PowerOn. As shown in Figure 2.

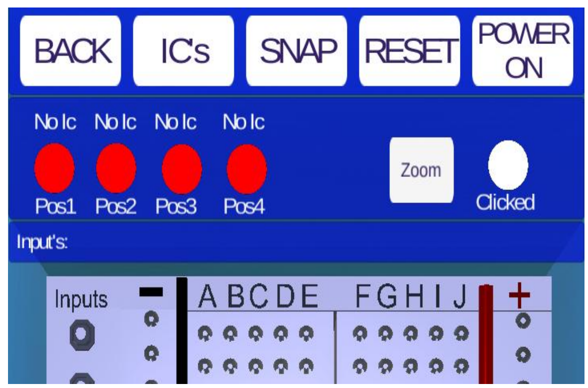

Figure 2: Upper menu in A.V.B.

Back Button will take user to the main menu screen whereas on clicking IC button, Side panel containing IC's will appear from where user will be able to drag IC to the breadboard as shown in Figure 3.

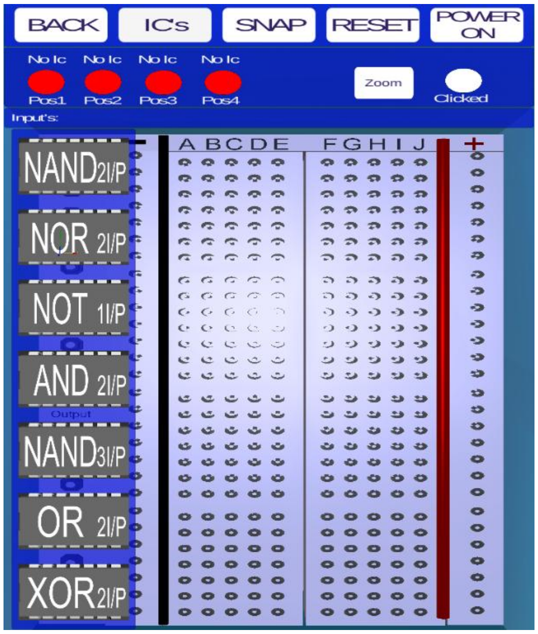

Figure 3 Side Panel to drag and pan IC's

There are four different partitions where IC can be placed and on placing IC on right position will turn the top indicator from red to Green specifying that IC is on right position as shown in Figure 4 and now circuit can be created by tapping on the different points on the breadboard.

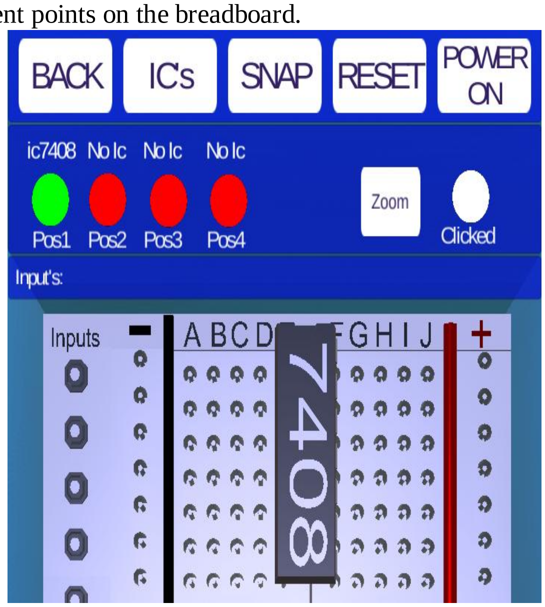

Figure 4: Pos1 indicator changes to green after placing IC on right place.

Different wire colors are used for connections so that it distinguishes between input, output, power and faulty connections as shown in Figure 5. Red color specifies the faulted/ wrong connection, Blue color is reserved for input connections whereas green color is used to specify output connections, Black color wire indicates the ground connection and orange color represent positive connection as shown in Figure 6.

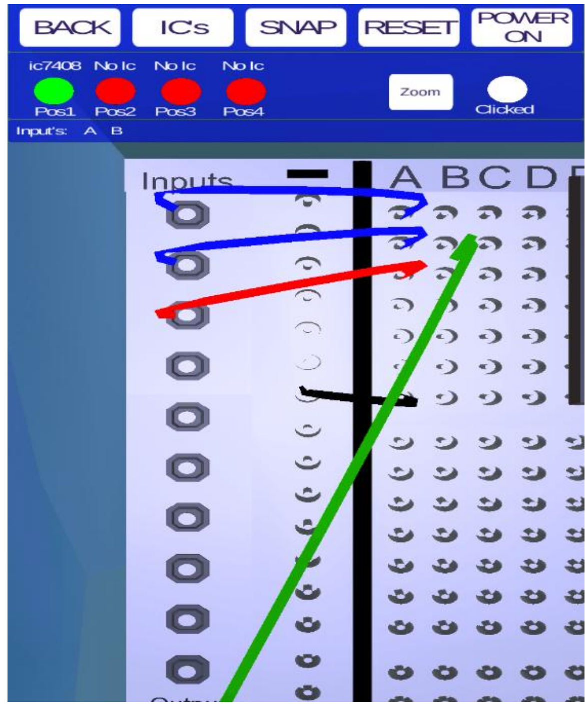

Figure 5: Different color combination used in A.V.B

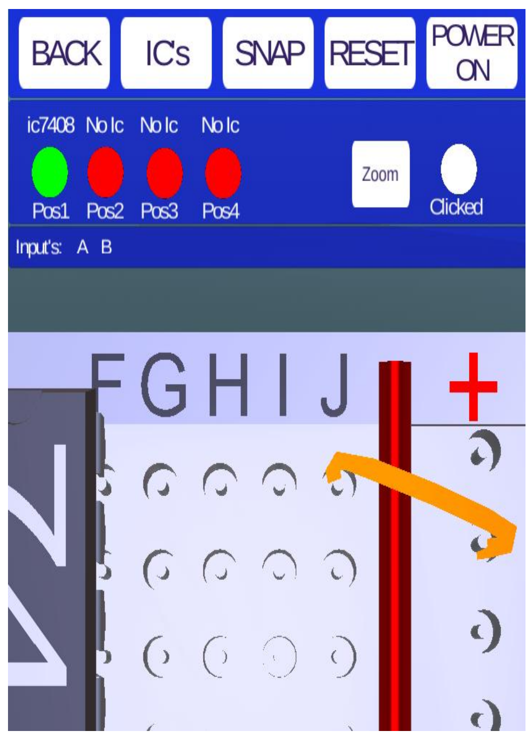

Figure 6: Color combination for positive connection used in A.V.B

Meanwhile while creating connections for input system asks for the alphabetic name to assign to input as shown in Figure 7.

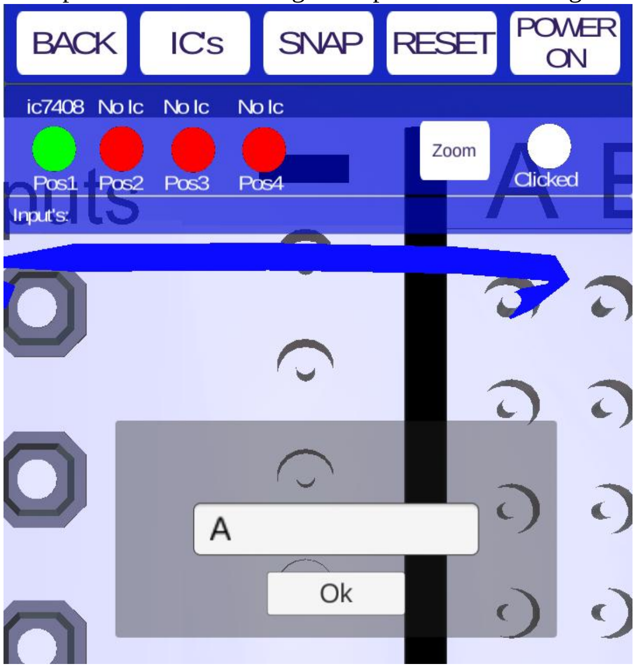

Figure 7: Assigning name to input

For viewing the internal structure user has to double click on the IC after placing it on the breadboard, Popup window will appear on the screen showing the internal structure. For deleting IC user has to click on the IC and then the bin will appear on the bottom right of the screen and user has to drag IC on bin as shown in Figure 8.

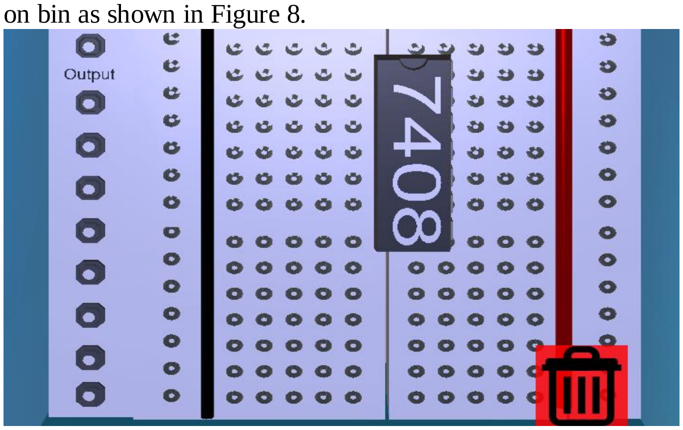

Figure 8: Deleting the IC from Breadboard

Snap button is used for capturing the screen and export the circuit in the form of PNG image format. Reset button is used for resetting the whole screen means loading blank breadboard while deleting all the connections and IC's that are placed on the screen.

PowerOn button is for verifying the connection and check either the power connections are placed or not. On successful verification next screen containing output will be displayed. Where user can tap on input buttons just like in real equipment (The only difference is that real equipment uses the flip button instead of one tap button) to check the functionality of logic gates embedded in IC.

After checking the functionality user has an option to view circuit diagram (as shown in Figure 9) or he/she can generate the truthtable (as shown in Figure 10) for the respective circuit that was created on the breadboard.

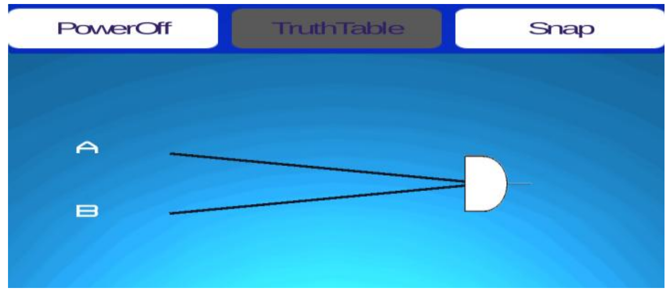

Figure 9: Circuit diagram generated for A & B that is from IC7408

Figure 10: TruthTable generated for A & B.

VI. Field Study

We conducted a field study to evaluate how much Android Virtual Breadboard (A.V.B) simulations are productive. Will students learn the same concepts as they learn on real equipment? Will students develop an understanding of using real equipment by working with simulations?

Working space: The place chosen for field is the Electronic Lab of National University of Modern Languages, Islamabad. User include the students of Software engineering and computer science of semester 4. And Lab engineer was there to help students and tell them how to create circuits on breadboard.

System: We implemented an android system A.V.B to create the simulations that are close to real equipment. The only difference is that A.V.B can show the circuit diagram and also support the generation of truthtable to match the result of circuit generation.

Implementation: Students were asked to install A.V.B in their smart phones to start the Lab then they were introduced to the real breadboard and they were taught how to implement circuits on the real equipment and then were asked to open the A.V.B and asked to implement circuits on it.

Data Analysis: For data analysis help of the subject teacher and lab engineer was taken. Time period for data analysis was 1 month in which we have to collect data for study. We use two methods for data analysis, 1st is taking data from lab engineer on daily basis and 2nd is from subject teacher who evaluates the student on weekly basis.

The data that was collected for analysis includes.

1. How easy it was for user to use A.V.B.?

2. Will students develop an understanding of using real equipment by working with simulations?
3. How much simulation is cost effective then real lab experiment?

Further we were interested that what is the difference of grade between 2 labs that are operated only on real equipment and the other that is additionally working with A.V.B. and real equipment?

VII. Results

As the observation is conducted in lab and the participant were student so they were excited that now they will learn something new via their smart phones. To compare results, we conducted separate labs for students of software engineering and computer science. There were 40 students in Software engineering and 38 students in computer science class. And field study was conducted for 1 month.

In study our first objective was to find out how easy it was to use the system. The results gathered are shown in Figure 11.

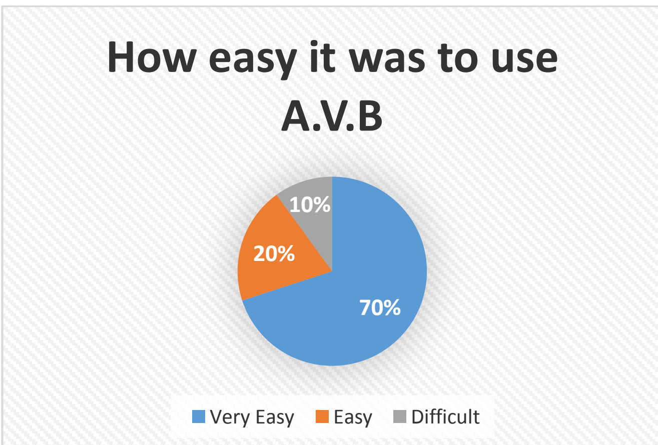

Figure 11 Data to show how easy it was to use A.V.B

Our second objective was to find out, how much students develop an understanding of using real equipment by working with simulations? For this we had to consult lab engineer, after getting data we get the following data (shown in Figure 12) of how many of class students successfully performed the same circuit experiment after developing it on A.V.B.

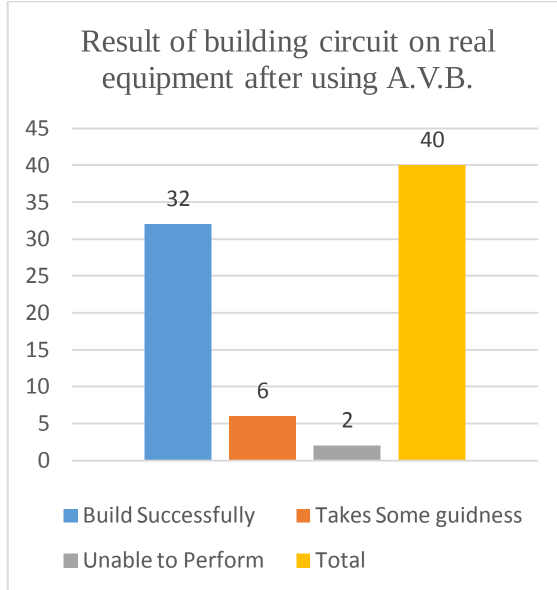

Figure 12 Result of using Real Equipment after using A.V.B

Students find it easier to develop circuit on A.V.B. than real equipment because of the complex mesh of wires, during discussion students told that due to different colors of wires we were confused and we have to retrace the connection before connecting another wire to circuit so we take more time on real equipment to build circuit. Whereas in A.V.B. proper colors are assigned according to the input, output, ground, positive and faults so it is easy to identify between different connection also it tells about the fault if any before power on the circuit.

Now the third objective in which we wanted to know how much A.V.B. is cost effective, for this we get weekly data of how many IC's short circuit (as shown in Figure 13) in lab of computer science.

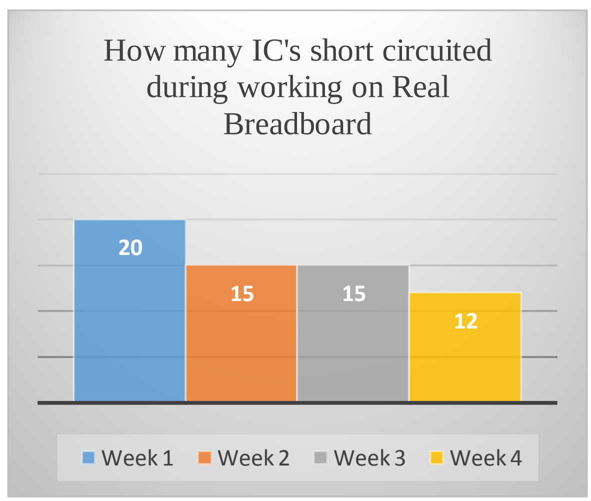

Figure 13 IC's Short circuit during the time period of Study

Final objective was to find out what is the difference of grade between 2 labs that are operated only on real equipment and the other that is additionally working with A.V.B. and real equipment? For this we consulted their subject teacher who conducted lab test fortnightly. The result after analysis was as follow.

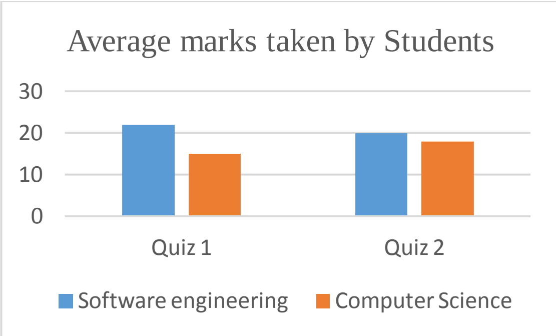

Figure 14 Average marks taken by Students

After collecting the result (shown in Figure 14), we concluded that students find it easier to use A.V.B. and those who use A.V.B. get more understanding of building circuits and they have better concept of how circuit was actually build. Students who use A.V.B. require less guideness yet more productive than those who worked only on real equipment. Another benefit that simulation has is that it is cost effective and error free, in most of the case labs don't have the required equipment to accommodate all students in the class, sometimes equipment got faults and desired results can't be achieved which slows down the learning process, so groups were made to perform experiments. A.V.B. removes the concept of faulty equipment also it enables students to perform experiment individually to gain better understanding.

VIII. Limitations

The limitations that are applied on AVB are:

1. A.V.B works only on seven basic IC's which is also the limitation of system, A.V.B cannot be used for the advance electronic labs in which they use arithmetic circuits, registers, ram, multiplexer, flip-flop etc. so it can only be used in electronics lab to teach beginners.
2. This system supports deploying of only four IC's at a time. Because of the limited space on android phone screen, user cannot deploy more than four IC's on breadboard. So A.V.B. doesn't support complex circuits that require more than 4 gates.

IX. Discussion

The present study suggests that it is possible, and in the right conditions preferable, to substitute virtual equipment for real laboratory equipment. Of course, there are many constraints on when and how this might occur, including but not limited to considerations of the context into which these simulations are embedded (both pedagogically and logistically).

We are not claiming that all electronics labs ought to be replaced, but rather the conventional wisdom that students learn more via hands-on experience is not borne out by measures of student performance on assessment of conceptual understanding, nor their ability to construct circuits. In an inquiry based lab, students using the simulations learned more content than did students using real equipment. Notably, the results on the final exam demonstrate that the students who used the simulation had a better mastery on building circuits.

No less significant, student facility constructing real circuits is supported by the simulations. The data suggest that students who have worked with simulations are more capable at constructing and writing about circuits than their counterparts who have been working with the physical apparatus all along. In addition to more correctly and thoroughly writing about the circuits, the students take less time on average than their counterparts at building and describing these circuits. However, in this case, we find that the virtual experience results in the greater student facility with circuits.

It is worth noting that simulations are subject to the same vagaries of breaking down that plagues real equipment. They can operate in unintended ways, and frustrate users as much as any mechanical or electrical device can. Furthermore, other researchers [11] note concerns that new tools may provide new educational difficulties.

Later they note that it is important that "appropriately timed 'reflective' points could be incorporated in the program enabling students to self-assess their understanding of concepts. Students should not be able to simply exit a screen with alternative concepts left intact (or reinforced)".

In while it may seem counterintuitive, the limited nature of investigation afforded by a simulation can be productive. That is, because the system under investigation is constrained in particular ways, students are able to make progress they cannot in an unconstrained environment. For example, students are not given the choice of wire color and hence do not attribute meaning to insulator color in the simulation. In the case of real equipment, wire color can serve as a distraction. Simulations provide the instructor considerably more freedom in designing and applying constraints to insure the students messing about leads to productive learning. As Otero finds, students use computer simulations productively to produce conceptual models that are then effectively applied to physical ("real world") applications. [12]

X. Conclusion

In these studies, students who utilized AVB performed better on calculated inquiries identified with simple circuits, and built up a more prominent office at controlling genuine components. We don't propose that simulations fundamentally advance calculated learning nor do they guarantee facility with real equipment, yet rather reproductions that are legitimately planned are helpful instruments for an assortment of settings that can advance student learning. In this specific environment the virtual hardware is more gainful than genuine gear. Reproductions are a long way from the enchantment slug many search for in instruction. In any case, we exhibit that android are basically valuable since they are pervasive and convenient in situations with generally limited resources. To simulate or not to simulate? Asks Steinberg [13]. Our answer is yes.

REFERENCE

[1] D. R. Sokoloff and R. K. Thornton, "Using interactive lecture demonstrations to create an active learning environment," The Physics Teacher, vol. 35, no. 6, 1997.

[2] R. Steinberg, G. Oberem and L. McDermott, "Development of a computer- based tutorial on the photoelectric effect," American Journal of Physics, vol. 64, no. 11, 1996.

[3] R. K. Thornton and D. R. Sokoloff, "Learning Motion Concepts Using Real-time Microcomputer-based Laboratory Tools," American Journal of Physics, vol. 58, no. 9, pp. 858-867, 1990.

[4] A. A. diSessa, "Changing Minds," in MIT Press, Cambridge, 2000.

S. Papert and I. Harrel, Situating Constructionism, Ablex Publishing Corporation, 1991.

[5] S. Turkle , "Seeing Through Computers," American Prospect, vol. 8, no. 31, 1997.

[6] Bernardo Guerra Pereira Cunha, Selmar Tarcisio Mendes and Priscila Maciel Dutra, "DidacTronic: A low-cost and portable didactic lab for electronics: Kit for digital and analog electronic circuits," Global Humanitarian Technology Conference (GHTC), 2016.

[7] S. Johnson and Thomas, A. P, "Squishy Circuits: a tangible medium for electronics education," in CHI EA '10 CHI '10 Extended Abstracts on Human Factors in Computing Systems, New York, NY, USA, 2010.

[8] D. A. Mellis, S. Jacoby, L. Buechley, H. Perner-Wilson and J. Qi, "Microcontrollers as material: crafting circuits with paper, conductive ink, electronic components, and an "untoolkit"," ACM, pp. 83-90, 2013.

[9] J. Qi and L. Buechley, "Sketching in circuits: designing and building electronics on paper," in CHI, 2014.

[10]S. Yeo, R. Loss, M Zadnik, A. Harrison and D. Treagust, "What do students really learn from interactive multimedia? A physics case study," American Journal of Physics, vol. 72, no. 10, 2004.

[11] V. K. Otero, "Cognitive processes and the learning of physics," in Proceedings of the International School of Physics "Enrico Fermi" Course CLVI, Varenna, Italy, 2003.

[12] R. N. Steinberg, "Computers in teaching science: To simulate or not to simulate?," American Journal of Physics, vol. 68, no. S1, 2000.