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A Dynamic Network Approach for E-Learning Based Electronics Virtual Lab to Mitigate COVID-19

Tamer M. Nassef
Misr University for Science and Technology || Egypt
Ayman Haggag
Sameh Nessim
Alaa Yousry
Helwan University || Egypt
Ashraf Aboshosha
Atomic Energy Authority || Egypt

Abstract: During the pandemic spread of COVID-19, it is very essential to develop modern and technology-based alternatives for traditional education. Virtual laboratories promote education and will be used in the future as the primary instructional instruments. Learning in a virtual laboratory minimizes teachers' worries about time, expenses, or hazards involving choosing improper, ineffective, or possibly harmful experimental approaches and fulfills the urgent need for social distancing to avoid the spread of infectious diseases. It offers higher student-to-component interaction and perception. Learning in a virtual lab enables more data to be obtained. The purpose of this research study is to train the student for practical application and experiment with measuring tools such as voltmeters and data acquisition systems. The student can also compare two outputs: the first is the outcome of the actual scheme, and the second is the virtual signal, the pure sine wave that can be regulated by frequency, amplitude, and phase. It can also send and obtain information from the teacher to the student. The teacher can see and follow up on what the learners are doing, so the teacher can better regulate the classroom. Experimental results show the superiority and the success of our proposed method in enhancing students' learning experience.

Keywords: E-learning, Ethernet shield, protocol TCP/IP, Arduino UNO.

نهج شبكة ديناميكي لمختبر إلكتروني قائم على التعلم الإلكتروني للتخفيف من COVID-19

تامر منير ناصف
جامعة مصر للعلوم والتكنولوجيا || مصر
أيمن حجاج
سامح نسيم
علاء يسري
جامعة حلوان || مصر

أشرف أبو شوشة
هيئة الطاقة الذرية || مصر

الملخص: أثناء انتشار الوباء COVID-19، من الضروري جداً تطوير بدائل حديثة قائمة على التكنولوجيا للتعليم التقليدي. تعزز المختبرات الافتراضية التعليم وستستخدم في المستقبل كأدوات تعليمية أساسية. يقلل التعلم في المختبر الافتراضي من مخاوف المدرسين بشأن الوقت أو النفقات أو المخاطر التي تنطوي على اختيار مناهج تجريبية غير مناسبة أو غير فعالة أو ضارة ويفي بالحاجة الملحة للمسافة الاجتماعية لتجنب انتشار الأمراض المعدية. وهو يوفر تفاعلًا وإدراكًا أعلى بين الطلاب والمكونات. يتيح التعلم في المختبر الافتراضي الحصول على مزيد من البيانات. الغرض من هذه الدراسة البحثية هو تدريب الطالب على التطبيق العملي وتجربة أدوات القياس مثل الفولتميتر وأنظمة الحصول على البيانات. يمكن للطالب أيضًا مقارنة ناتجين: الأول هو نتيجة المخطط الفعلي، والثاني هو الإشارة الافتراضية، وهي موجة جيبية نقية يمكن تنظيمها بالتردد والسعة والمرحلة. يمكنه أيضًا إرسال معلومات من المعلم للطالب والحصول عليها. يمكن للمعلم رؤية ومتابعة ما يفعله المتعلمون، حتى يتمكن المعلم من تنظيم الفصل بشكل أفضل. تظهر النتائج التجريبية تفوق ونجاح طريقتنا المقترحة في تعزيز تجربة تعلم الطلاب.

الكلمات الرئيسية: التعلم الإلكتروني، درع إيثرنت، بروتوكول TCP / IP، Arduino UNO.

1- INTRODUCTION

There is a prevalent issue nowadays that learners of science and engineering lack the professional understanding and abilities of communication between parts and devices. Students cannot exercise and obtain data with the theory and research methods. Among some technical colleges, these issues are becoming more prominent. [1]

The e-learning environment is seen as a significant resource for helping ancient traditional formats of learning and transforming the nature of education. We will design the virtual lab in this research using the "Lab View" program to provide learners with a distinctive manner of providing the e-learning environment with higher interaction between them and the element. [2]

Laboratory environment relates to the laboratory that colleges and educational organizations are building for student teaching. The classroom lab is a significant component of the setting of teaching and learning. It provides students with a useful, safe, and intuitive place to do scientific experiments. The experiment can stimulate interest in learning, experience the fun of exploration, enhance the current knowledge framework, and enhance operational, diagnostic, analytical, design, and innovation capabilities. [3]

E-learning is one of the most significant learning techniques in the future, so many studies are showing the significance of e-learning and the most significant studies in this sector or implementation are: Abdullah-Alhabeeba et al [19] also addressed the notion of e-learning, explaining the mechanisms of e-learning and explaining the distinction between traditional techniques of learning and e-learning.

The current health and safety constraints imposed because of the widespread of COVID-19 pandemic and the fear from the second wave of infections and fatalities necessitates the development of remote learning tools to allow for social distancing and avoidance of direct contacts between teachers and learners and between learners and other learners.

M. Travassos Valdez et al [4] addressed one of the key educational instruments in the future, i.e. 3D Virtual Labs, and designed a plan for Electrical Engineering lessons that aim to train learners to meet competitive difficulties.

Fuan Wen et al [20] addressed the notion of Experimental Enhanced Educational Environment (4E) and clarified the benefit of the 4E, which brings together the theoretical survey, experimental operation, cooperation, communication, and social exercise as the person who is the subject of the research. It also enables education to open a true application at a reduced price and enables learners to adapt more efficiently to future development.

The contribution of this research is in these studies that focused on and discussed safe learning at lower-cost technical schools and the use of professional software programs like "LabVIEW," "Team Viewer" and "Circuit Wizard" for two purposes in these studies: the first is safety learning in the electronic laboratory and the second is to train the student for practical implementation. Figure 1 indicates the front panel of our proposed system.

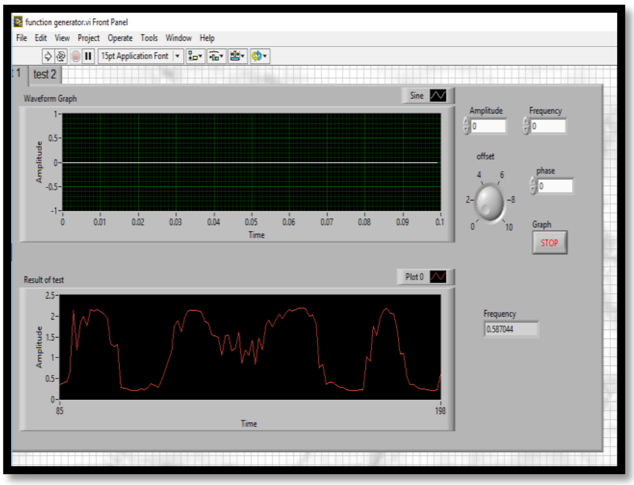

Figure 1. The front panel of our proposed system

So helpful and simple is the "LabVIEW" programming, so it is used in the project. It includes many items such as terminals, constants, structures, features, and sub-VIS (sub-virtual instruments). "LabVIEW "enables users to design their apps by dragging and dropping these items onto a diagram and linking them through cables. All terminals in the block diagram are shown in the front panel window (the virtual instrument's graphical user interface) which acts as input or output of information. "LabVIEW" utilizes different protocols like TCP/IP, socket data, etc. To transfer data between student and teacher, it will use the Ethernet module with the TCP/IP protocol. The team viewer software will also be used to transfer data and signals between the computer of the student and the computer of the teacher. [7]

The sampling speed of the oscilloscope is limited by the baud rate of the UART. The Arduino sketch is coded to read the ADC using ISR, and the UART baud rate is configured at 9600, which sends data at 80μs intervals. This gives an effective sampling rate of 10kSa/s.

The rest of this article is organized as follows: Section 2 talks about the proposed methodology of our teaching tool and Section 3 reviews the result Section 4 explains E-learning and Section 5 is the conclusion.

2- METHODOLOGY

The virtual lab system's design is divided into two components: The software is the first component in "LabVIEW" and LAN Network, and it designs and simulates the Cisco Packet tracer and the student can test circuits in the circuit wizard software and can also transfer the test outcome using the Team Viewer software. The second component is the Arduino, Ethernet, Current Sensor, and Temperature Sensor LM35 hardware. Using the circuit wizard software, all of these components can be canceled because it can simply simulate the circuit in the software without any cost or danger. The project's block chart is shown in figure 2, and the LAN network simulation is shown in figure 3, 4.

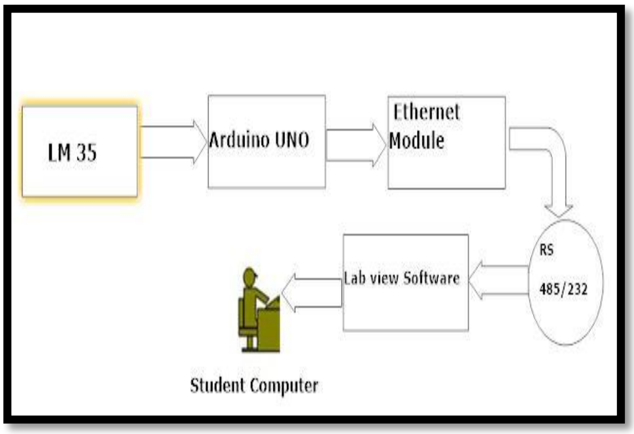

Figure 2. Block diagram

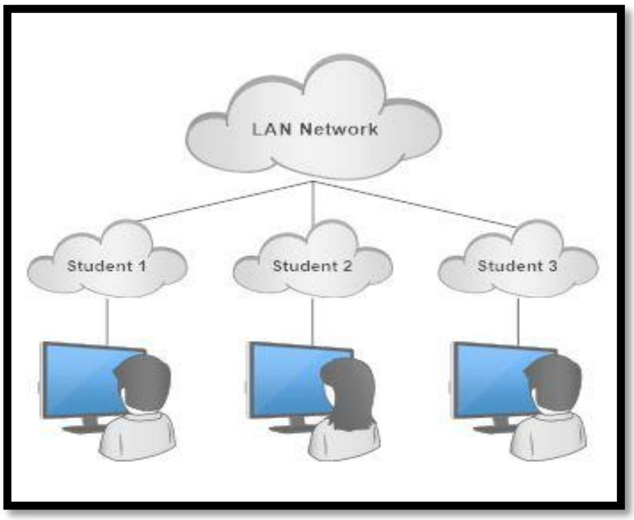

Figure 3. LAN Network

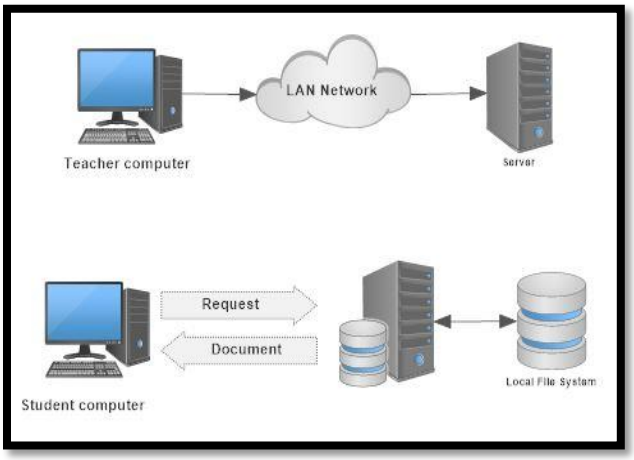

Figure 4. local Network in classroom

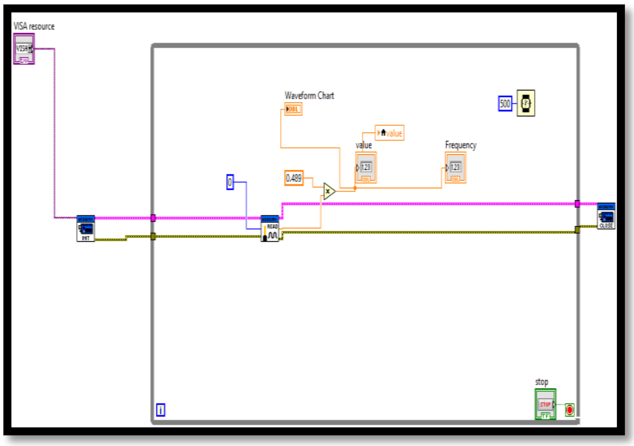

Figure 5. Analog signal input for Arduino

2.1 Software

The system design is split into two components: LabVIEW software is the first component. We will design a system that can also be used on the student's and teacher's desktop to simulate the Voltmeter and the information acquisition systems. We will design a unique program that will be able to link the laptop of the teacher and the computer of the student using TCP/IP. The second aspect is the LAN network designing and simulating using the Cisco Packet Tracer. [8] [9] [10]

2.1.1 LabVIEW software

You must first pick the component, structures, and operate to design the project's block diagram. Second, connect them via cables, and this is a significant move. Select Analog Read Pin block to read Arduino's analog signal input and select pin (A0). The analog signal input block diagram is shown in Figure 5. The Wave chart is used to display the element test outcome. We use the Simulate Signal feature to produce a sine wave or any wavy shape as shown in Figure 6. We design the data transfer program using TCP/IP protocols. We design a program on the master computer to send the information through a port, but on the client computer, you need to pick this port. Select the byte of information to read, as shown in Figure 7. We design a program for receiving information on the client's computer. The program requests the information again in the event of a communication issue. Figure 8 shows the block diagram. [15]

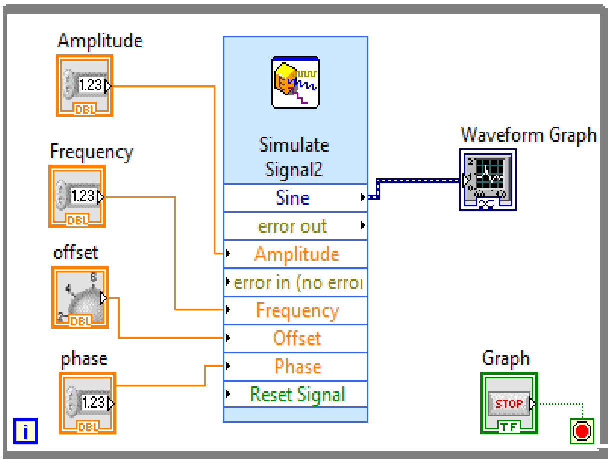

Figure 6. Functions Simulate Signal

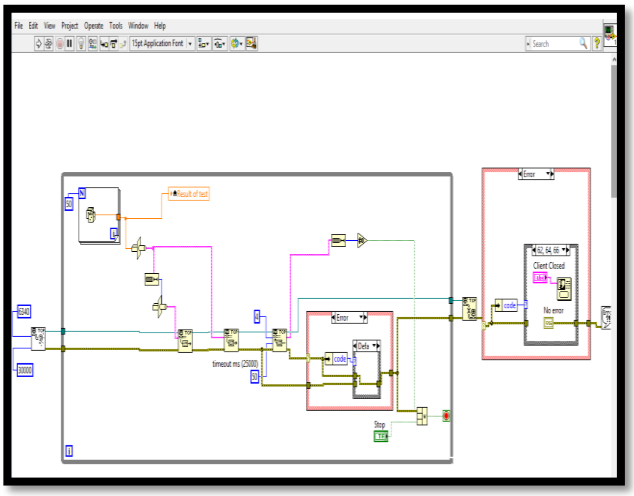

Figure 7. TCP/IP protocol (master computer)

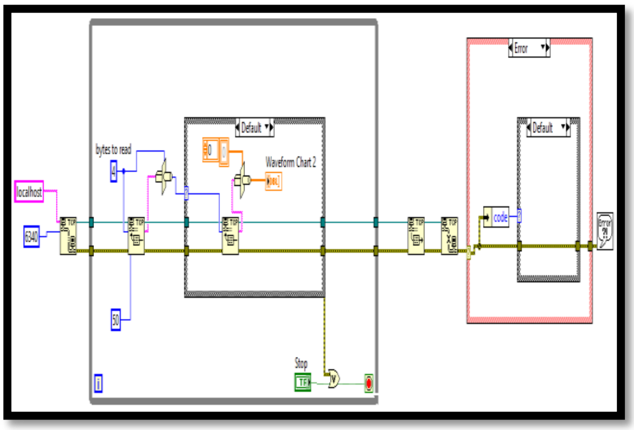

Figure 8. Program of TCP/IP in the client computer

2.1.2 Cisco Packet tracer software:

It is very essential to simulate the network that begins execution, so we will design a visual simulation to generate network topologies and imitate contemporary computer networks. The software enables users to use a simulated command-line interface to simulate the setup of Cisco routers and switches. Packet Tracer uses a user interface to drag and drop and enables users to add and remove simulated network devices as they see fit. Figure 9 shows the simulation scheme. [14] [13] [5]

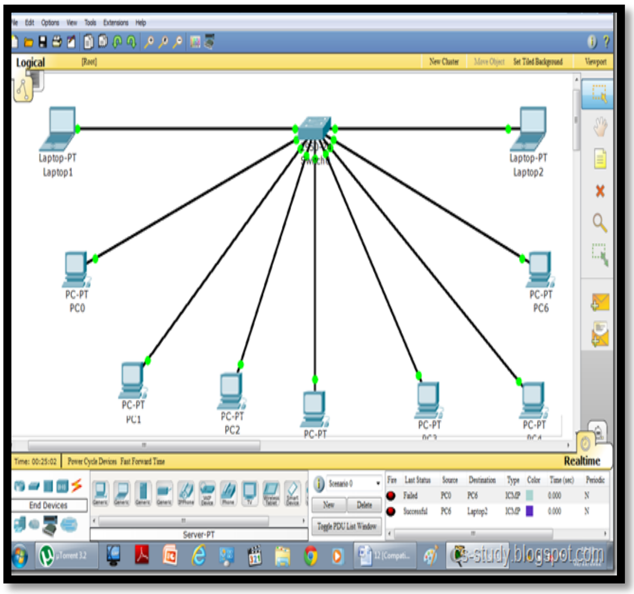

Figure 9. Simulation System

2.1.3 Circuit Wizard Software

This program is used to simulate electronic components and measuring instruments, as simulating the conduct of a circuit before it is built can significantly enhance the effectiveness of the design by creating defective models and offering insight into the conduct of electronic circuit models. For integrated circuits, the tooling (photomasks) is particularly expensive, breadboards are impractical, and internal signal behavior is extremely difficult. Therefore, almost all IC designs rely heavily on the simulation. SPICE is the most common simulator of analogs. Those based on Verilog and VHDL are probably the best established digital simulators [12] [11] [6].

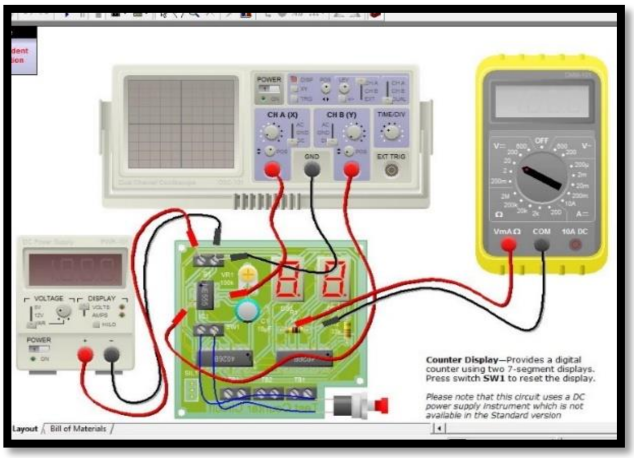

Figure 10. Simulation measurement system

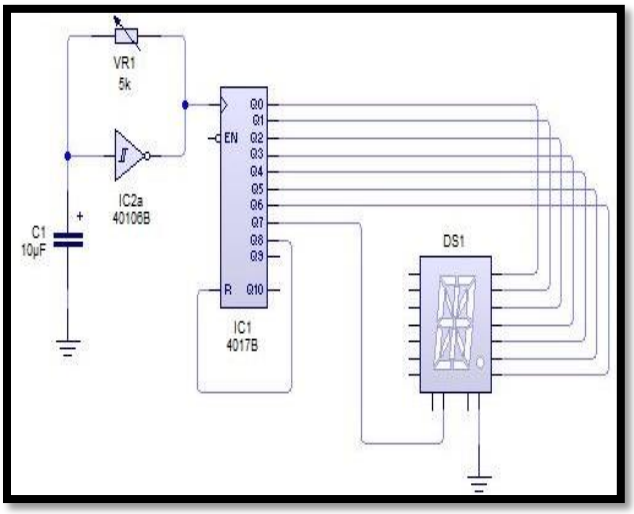

Figure 11. Simulation Starburst Display

2.2 Hardware:

The primary parts of the system are the Arduino and Ethernet modules. The Arduino is the system's brain, which is used to transform signals between the PC and the Ethernet module. The Arduino is used to read analog signals from LM35 and make some functions to view the signal wave on a wave graph in the front panel. The Ethernet module is used to transfer data between the master computer (teacher) and the client computer (student), and you can store a file on a micro-SD card.

2.2.1 Arduino UNO

The Arduino Uno is an ATmega328 based microcontroller board. It has 14 digital input/output pins (including 6 as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller and simply connecting it to a computer with a USB cable or power it with an AC-to-DC adapter or a battery to get started [18]. This is shown in figure (12).

The ADC of Arduino can measure voltages up to 5V. So it is advisable to add a small protection circuit to limit the input voltage to 5V and clamp the negative voltage. A low-power, fast-switching diode like 1N4148 can be used to protect the input pin. Connect a 10-kilo-ohm resistor in series with the input. It will work as a current limiter in case the input goes beyond 5V. Additional voltage dividers can be used in case you need to measure voltages higher than 5V.

Figure 12. Arduino UNO

2.2.2 Ethernet Shield

The Arduino Ethernet Shield enables an internet connection to the Arduino board. It is based on the Ethernet chip Wiznet W5100. The Wiznet W5100 offers a TCP and UDP network (IP) stack. It supports up to four connections simultaneously to the socket. Use the Ethernet library to create designs that use the shield to link to the internet. The Ethernet shield uses lengthy wire-wrap headers that extend through the shield to connect to an Arduino board. This keeps the layout of the pin intact and enables stacking on top of another shield. The shield's recent revision provides a micro-SD card slot that can be used to store files for network service. It is compatible with Arduino Duemilanove and Mega (using Arduino 0019's Ethernet library). A normal RJ45 Ethernet jack is provided by the shield.

The shield reset button resets the W5100 board as well as the Arduino board. The shield contains several informational LEDs: PWR: indicates that the board and the shield are powered LINK: indicates the presence of the network link and flashes when the shield transmits or receives data FULLD: indicates that the network connection is full duplex 100M: indicates the presence of a 100 Mb/s network connection (as opposed to 10 Mb/s) RX: flashes when the shield receives data TX: flashes when the shield sends data

COLL: flashes when network collisions are detected. The solder jumper marked "INT" can be linked to enable the Arduino panel to obtain interrupt-driven event notifications from the W5100, but the Ethernet library does not support this. The jumper connects the W5100's INT pin to the Arduino's digital pin 2. [17]. Figure 13 shows this.

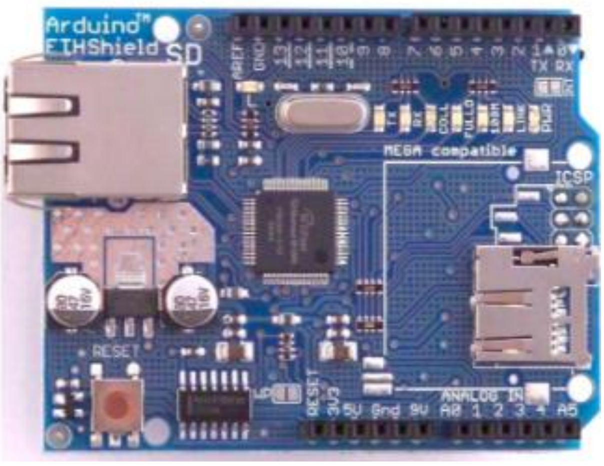

Figure 13. Ethernet Shield

2.2.3 LM35 Precision Centigrade Temperature Sensors

The LM35 series are precise integrated circuit temperature instruments with a voltage output linearly proportional to the temperature in Centigrade. The LM35 device has a benefit over Kelvin-calibrated linear temperature sensors, as the user does not need to remove a big constant voltage from the output to achieve convenient Centigrade scaling. To provide typical accuracies of ±1⁄4 °C at room temperature and ±3⁄4 °C, over a full −55 °C to 150 °C temperature range, the LM35 instrument does not involve any internal calibration or trimming. Cutting and calibration at the water level ensure lower costs. The LM35 device's low-output impedance, linear yield, and accurate intrinsic calibration that makes interfacing particularly simple to read or control the circuitry. The unit can be used with single or plus power supplies and minus supplies. As the LM35 device draws only 60 μA from the supply, it has a very low self-heating of less than 0.1 °C in still air. The LM35 device is rated to operate over a −55 °C to 150 °C temperature range, while the LM35C device is rated for a −40 °C to 110 °C range (−10 °C with improved accuracy). The LM35-series devices are available in hermetic TO-transistor package, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package. It's shown in Figure 14.

Features of LM35D is that it can be Calibrated Directly in Celsius (Centigrade) with Linear + 10-mV/°C Scale Factor and 0.5°C Ensured Accuracy (at 25°C). It is Rated for Full −55°C to 150°C Range and Suitable for Remote Applications. It has Low-Cost Due to Wafer-Level Trimming and Operates from 4 V to 30 V with Less Than 60-μA Current Drain and Low Self-Heating, 0.08°C in Still Air. It has Non-Linearity of Only ±¼°C Typical and Low-Impedance Output, 0.1 Ω for 1-mA Load.

The Applications of LM35D are in Power Supplies, Battery Management, HVAC, and other Appliances [16].

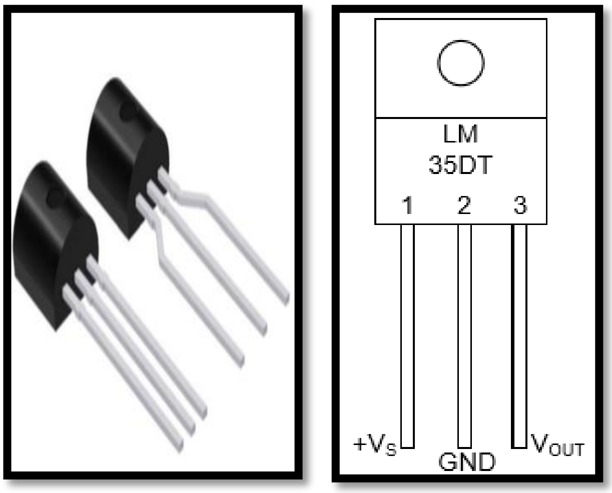

Figure 14. LM35

3- RESULTS

3.1 Data Acquisition Systems

The system can be used to evaluate the voltage value at any component as a voltmeter and data acquisition scheme. Learners can choose from two alternatives: Volt is the first choice and Kilo Volt is the second alternative. Figures 15 and 16 show the block diagram.

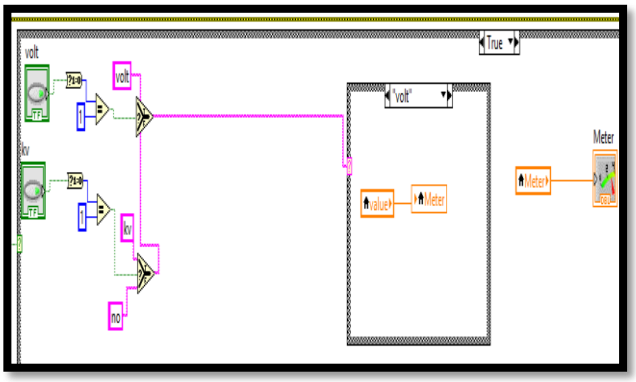

Figure 15. Block diagram when select volt option.

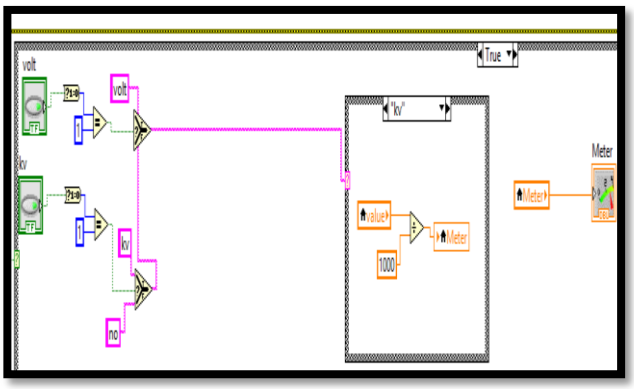

Figure 16. Block diagram when selecting the Kvolt option.

Figure 17. The front panel of Voltmeter (Virtual)

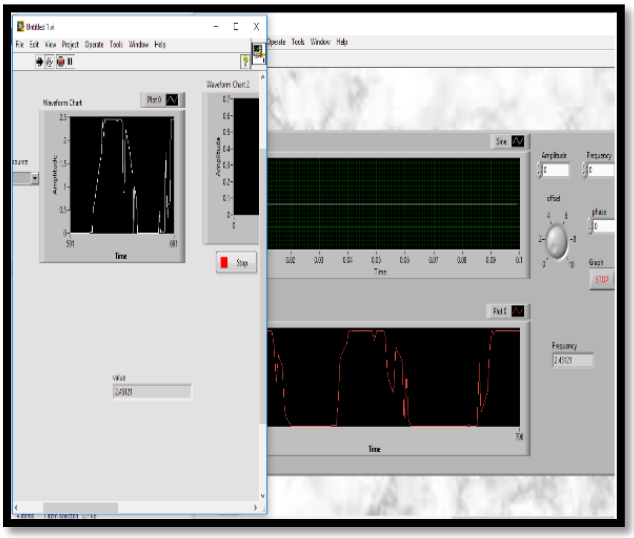

Figure 18. Send and receive data between the computer of the teacher and the computer of the student by using TCP/IP protocol

3.2 Advantages of Proposed System

The benefits of our proposed system can be summaries in the following points. Experiments can be tailored to the needs of the student and experiments can be reproduced easily. It is possible to set up simulations more variable than practical tests. Simulations can provide a tool to facilitate learning unobservable experimental situations. Current tests can be too complicated and/or costly.

Actual experiments can be too dangerous. Learning doesn't depend on a specific time and place. The hypermedia structure supports the exploration of the learning content. The learning materials can be adapted in the learning environment to the needs of the learner.

4- E-LEARNING SYSTEM

Throughout this research, we introduced a survey to 5 classes at Helwan University and the Arab Administrative Development Organization using their e-learning programs; MOODLE, QUIZLET, and Google CLASSROOM. The students' favorable reaction promotes us to proceed later where immediate follow-up reaches more than 90% and students' satisfaction exceeds 92%. Figure 19 demonstrates these programs in a snapshot

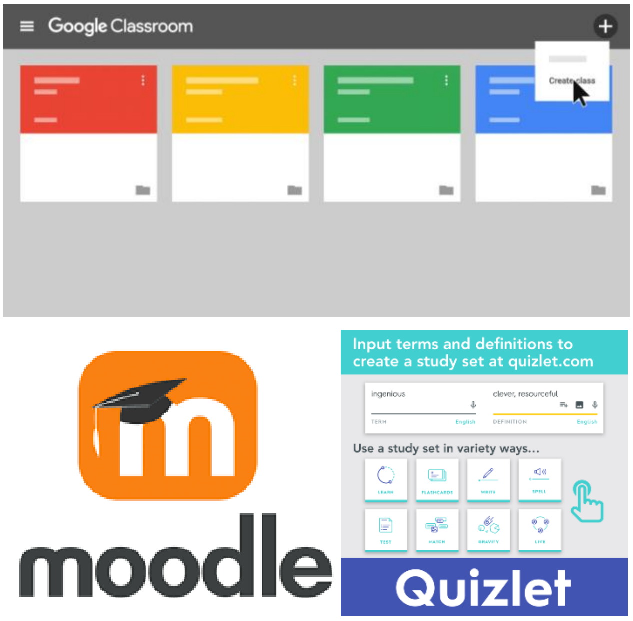

Figure 19. Google Classroom, MOODLE and QUIZLET

5- Evaluation of the Proposed System

After practical implementation and experimentation of our proposed method with students, we found that our proposed system has the following benefits. Experiments can be tailored to the needs of the student and experiments can be reproduced easily. It is possible to set up simulations for more variables than practical tests. Simulations can provide unobservable experimental situations. Current tests can be too complicated and/or costly. Actual experiments can be too dangerous. Learning doesn't depend on a specific time and place. The hypermedia structure supports the exploration of the learning content. The learning materials can be adapted in the learning environment to the needs of the learner. Figure 20 shows the executive scheme of the implementation of our prosed method.

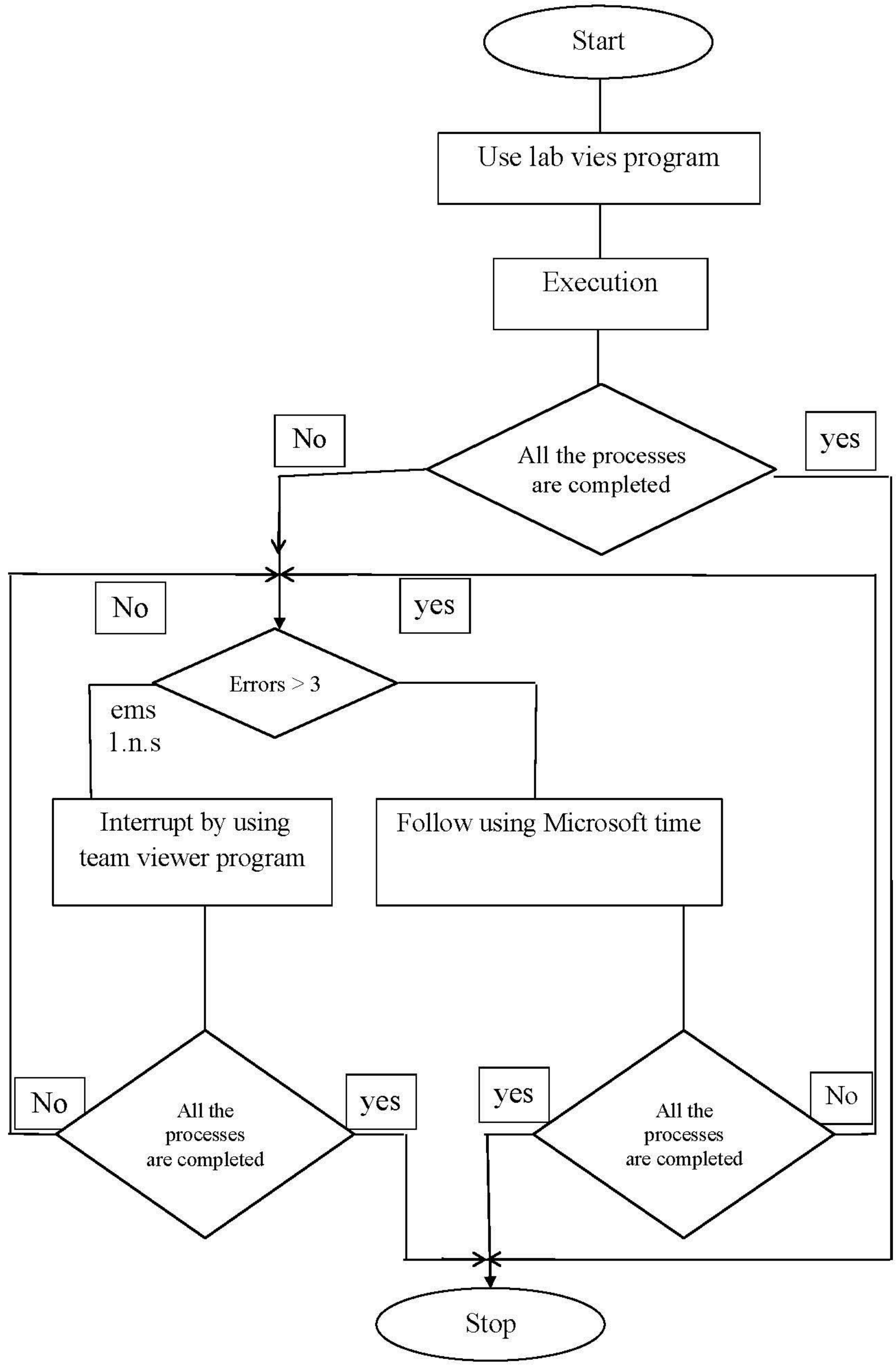

Figure 20 Executive scheme of the implementation of our proposed method

Table 1 shows a comparison of features of Moodle-based tools and their effect in facilitating remote learning and assessment of students during the COVID-19 lockdown period.

Table 1. Comparison of Features of Moodle-based Tools

Tool	Statistical Analysis	Clustering Analysis	Classification	Visualization	Language Used
ViMoodle	No	No	No	Yes	Java
E-learningWebMiner	No	Yes	No	Yes	Java
IntelliBoard.net	No	No	No	Yes	PHP
SmartKlass	No	No	No	Yes	PHP
Analytics graphs	No	No	No	Yes	PHP

From Table 1, we can see that the existing tools that are used for the analyses Moodle data are developed using PHP and Java and they are mainly aiming to provide statistical results and visualization of learners' progress data.

6- CONCLUSION

The research primary purpose is to use it in classrooms. Learning in the setting of virtual laboratories or e-learning offers higher interaction with elements. The new technology enables the job to be carried out without influencing the outcome quality. Virtual lab education offers better efficiency in teaching and learning procedures at a greater level. A desirable scenario will have courses and/or curricular units given in the distance learning mode, allowing the students to access the practical laboratory work from home or work. Statistical analysis and evaluation results showed the feasibility of our proposed method in delivering remote educational and learning experience that is superior to traditional methods without the risk of direct interactions and possible infections due to direct contacts where immediate follow-up reaches more than 90% and students' satisfaction exceeds 92%.

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