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MICROCOMPUTER-BASED LABORATORY (MBL) SYSTEM WITH AUTOMATED MEASURING APPROACH FOR BASIC ELECTRONICS

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ABSTRACT

Basic electronics experiments are essential in providing fundamental foundation in electronics. Hence, this work proposes an automated measuring microcomputer-based laboratory (MBL) system specifically for basic electronics and instrumentations experiments in pre-university level. Development process including hardware and software (module) will be discussed in details. Developed gadget utilizes Phidget Interface Kit and sensors for real-time data acquisition of voltage and current and sending it through USB (Universal Serial Bus) to personal computer (PC). LabVIEW used as the graphical interface to control data acquisition and analization. MBL module has been designed to represent the data interactively on the computer screen as well as an interactive laboratory teaching kit. Furthermore, voltage and current measurement were successfully merged with on-board electronics components for simplified experimental setup. This system was designed to be compatible with two types of sensors. It provides two input channel and also can be utilized as an oscilloscope on the computer screen. At low development cost, this sleek and compact system is expected to enhance student's performances and attitudes towards the laboratory work in basic electronics. This claim will be validated later and it will be included as a future work

Keywords: Basic Electronics, Instrumentation, Microcomputer-Based Laboratory (MBL) Sensors

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I. INTRODUCTION

Most countries are heading towards attaining their own targets in various aspects and the vision for continuous and progressive nation development. Years by years, there's a number of efforts towards achieving its goal to become a higher income nation through human capital development. A quality education system needs to be generating in order to produce integrated skilled and innovative man power towards future.

Learning electronics is often considered to be a difficult pursuit by students all over the world. Understanding its fundamental theories is a must to ensure deeper conceptual understandings and create self-confidence during practical sessions. The latter is a key for university students to sustain their technical skills and techniques since they are somehow expected to fulfill technical know-how job market. Basic electronics experiments cover several subtopics namely voltage-current measurements, Ohm's law, RC circuits and diode characterization. Over the last two decades, a great deal of educational research has been directed towards the exploration of students' ideas and difficulties on physical concepts, processes and suggestions to overcome them which includes experimental work. It was found earlier that many students cannot meaningfully summarize the important aspects of an experiment that they have just completed (Reif & Mark, 1979).

Usually they recall some of their manipulations in the laboratory, but unable to articulate the central and true goal of the experiment. They also consider it neither particularly interesting nor enjoyable. Students' understanding of electrical field, potential difference, resistance, and capacity has been investigated in different studies (Liegeois, Chasseigne & Papin, 2003) Students can't see what happen when a current of electrons flow through a circuit, hence makes it problematic to understand (Carlton, 1999). Defective procedural knowledge is often evident in the problem solving approaches employed by most of the students. Research findings also suggest that a conventional or traditional laboratory instruction is ineffective in dealing with misconceptions. Student often confuse between resistor and resistances, and face major difficulties when using graphical representations.

Several investigations have been done similar studies to define misconception about simple electric circuits (Lee & Law, 2001; Shipstone & Cheng, 2001). Some proven evidence suggests that the laboratory parts of physics courses at many other schools suffer from similar difficulties. It was clear from the responses that severe laboratory problems in the electronics laboratory are prevalent and are extremely diverse in nature (Noorhisham, 2011)). Besides that, several simulation-based learning and traditional laboratory learning were explored and compared in the context of physics studies (Chang, Chen, Lin & Sung, 2008). A prototype introductory physics laboratory had been designed to teach students some general intellectual skills widely useful in scientific work, which include both basic skills (estimating quantities, determining errors, or applying useful measuring techniques) and higher-level skills (effectively describing experiments and flexibly adapting the resulting knowledge to different condition) (Reif & Mark, 1979).

Innovation and improvements in computer technology have made automated measurement more applicable to different characterizing process. Schools' widespread access to information and communication technologies (ICT) poses tremendous challenges to physics laboratory teaching and learning (Jimoyiannis & Komis, 2001; Celia, 2010 & Fauziah, 2010). A number of researches have been done on the study of the effects of various types of teaching interventions in order to help student improves their physics laboratory performances and attitudes toward the basic electronics experimental work.

Recently, it was found that automated data allows student to focus more on the experiments and the underlying physics compare to spending most of the time collecting and plotting data for later analysis (Fernandes, Ferraz & Rogalski, 2010). The availability of modern graphical programming language that can do measurement and data analysis such as LabVIEW makes automation and measurement process easier [1]. The consideration of choosing LabVIEW as it is easy to program, user friendly, and compatible for many hardware devices [2]. Instead of using text-based programming, one can graphically assemble the virtual instruments based on the block diagram. LabVIEW also can produce reliable data of non-linear curve fitting algorithm [3].

To date, there is no reported study on the usage of interactive data logger specifically for pre-university students taking electrical related courses. The main purpose of this paper is to propose a development of microcomputer-based laboratory system via automated data acquisition and measurement using graphical programming language LabVIEW which creates software laboratory modules for Basic Electronics experiment. Phidget Interface Kit and Phidget sensors are used to establish serial communication via USB from sensor to personal computer in order to obtain the I-V data and I-V characteristics of diode. Hence, this microcomputer-based laboratory system with automated measuring approach was to improve students' performance in laboratory sessions towards generating more highly skill and quality student in future.

II. SYSTEM COMPONENTS

A microcomputer-based laboratory learning system consists of a data logger which interface directly with an interactive teaching module was designed. Data logger is an electronic device that records data over time. Usually, portable data loggers function as a stand-alone device to collect and store raw data. However, data processing and analysis need to be done separately. This type of data logger suitable for remote monitoring purposes as demonstrated recently (O'Flynn *et. al*., 2010). Another type of data logger requires desktop or laptop PC to function. Interface between data logger and computer can be done using several protocols via multiple ports such as parallel, serial (DB9) and USB (Viswananthan, Lisensky & Dobson, 1996). In this case, specific software is required [17] so that computer can receive and process raw data and interpreted it to a meaningful and readable quantity as measured. By connecting data logger to a PC, real time data measurement is made possible. Data processing and representation could also be more interactive and attractive by utilizing graphical user interface (GUI) within software environment. Data logging system is popular and sometime essentials for medical instrument, industrial equipments, military and highly sophisticated applications (Fertitta, Stefano, Fiscelli & Giaconia, 2010) scientific research tools as well as an education apparatus (Walker, 2010; MacLeod, 2007). The existed data logger was found to be a stand-alone device, which did not have any interface neither with interactive software or any teaching module. In recent scientific education trends, computerize data logging system become essential and common, owing to the fast growth of computer technology. It was proven simplified the education process yet at the same time providing better convenience within processes [21].

Complete data logging and acquisition system usually comes with surprisingly expensive package depending to its ability and processing capacity. Custom made data logger for specific experiment modules are obviously came with even higher price which limiting the ability of our local schools, colleges and pre-university institution to own and maintain it. Even not a major, but it is one of the factors why our students still utilizing conventional measurements techniques with traditional apparatus for data collection during experiments. Electronics experiments that utilize traditional apparatus consume more time to set up and potentially require extra instruction and supervision. Error while reading those instruments and gauges are also an issue.

On the other hand, students' interest nowadays is diverted to computerize method. Data acquisition software is rather more popular than a conventional lab sheet. Besides, this data logger was interface with an interactive laboratory module which enables students to learn, explore and troubleshoot related problems. As such, this interactive data logger hope to provide solutions to the 1960s laboratory haunting problems by capitalizing on the computers as supported individualized teaching/learning tools for students.

III. HARDWARE DEVELOPMENT

The hardware utilized in this system are Phidget 8/8/8 Interface Kit, a user friendly controller for sensing environment from the computer and Phidget voltage sensors. The interface kit is easy to use even for people with no hardware knowledge. Analog output on the Interface Kit 8/8/8 is 10-bit values. Two Phidget sensors are used to acquire the voltage and current values. The sensors can measures DC voltages from -30 to +30 volts with typical error of ±100 volts. Voltage sensor is non-ratiometric where Analog-to-Digital converter on the interface kit reference itself to a regulated 5V references thus it is not relative to Vcc. First sensor is wired parallel to the diode under test and the sensor value is then converted to voltage reading. Second sensor is connected parallel to resistor in the circuit, converted to voltage reading and the voltage is divided with resistor value to obtain current across the circuit based on Ohm's Law V = I X R. Figure 1 shows the developed MBL system.

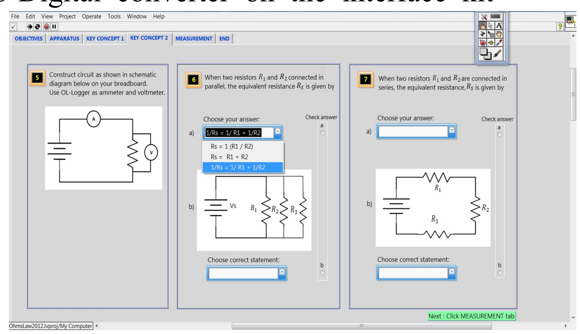

Fig.1. Developed MBL System

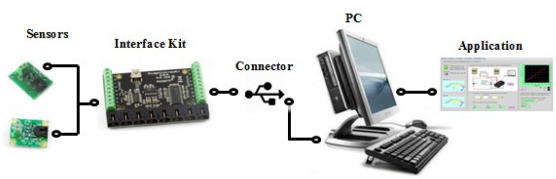

Fig.2. MBL Module Interface aligned with "Informing Objective" Gagne Instruction Events

IV. SOFTWARE DEVELOPMENT: MBL MODULE

Software development comprises of the design of Basic Electronics laboratory module which integrates with automated data acquisition through computer programming. This MBL module is designed based on the nine Gagne Instruction Events which are gaining attention, informing objective, stimulating recall, presenting information, providing guidance, eliciting performance, providing feedback, assessing performance and enhancing retention.

According to Gagne, the learning process is an information processing process that occurs internally in student's minds. Meanwhile, this internal learning process is found to be related to external teaching which an effective teaching can enhance the inner learning process [22]. Computer programming is done mostly using LabVIEW. Utilizing many GUI functions such as dialog boxes and buttons, voltage and current measurements were made as easy as a mouse click. Figure 2, Figure 3 and Figure 4 show interfaces of the developed MBL which aligned with the Gagne's teaching events.

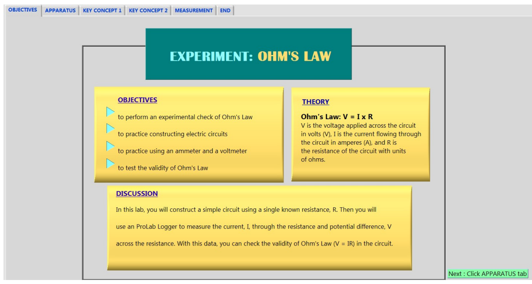

Fig.3. MBL Module Interface based on "Eliciting Performance" of Gagne Instruction Events

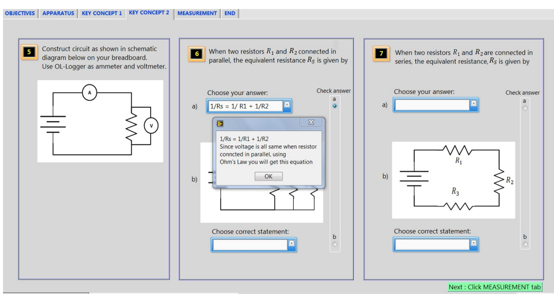

Fig.4. MBL Module Interface represent "Providing Feedback" Gagne Instruction Event

Figure 2 represent the module interface which "informing objectives" of the laboratory that will be run by students while Figure 3 shows the interface of "providing feedback" to users. When users pressed the check answer button, module with provide immediate feedback informing the answer is right or wrong together with explanation. As reported in Cyboran [23], feedback should be more than "your answer is correct" or "your answer in incorrect" and feedback should state why their answer is wrong. Besides interfaces of Gagne's Nine Instructions Events, this MBL module also been specifically designed for automated measurement which enable students to learn Basic Electronics practically through experiment. Figure 5 is the measurement interface which consisted of experimental setup, where the users were allowed to build the Ohm's Law circuit to measure voltage across the resistor and current flow through the circuit. The voltage and current are detected and measured from sensors in the logger. The left side of the page shows virtual ammeter and voltmeter showing the current and voltage value.

Users were provided with "MEASURE" control button to start the measurement of voltage and current. The "CALCULATE" control button is for user to automatically get value of resistor obtained from Ohm's Law equation. When user clicked the "PLOT" control button and increased the voltage supply from 0 to 12V, a real-time graph of Ohm's Law is generated as shown in the right side of page. The interface of this page also demonstrates the use of bright colors to attract users and give mood to run the experiment which aligned with one of Gagne Instruction Event; "Gaining Attention".

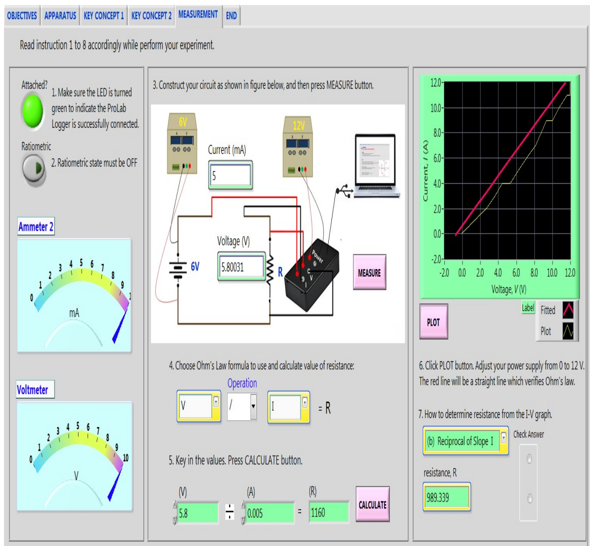

Fig.5. MBL Module Interface for Automated Measurement

V. OUTCOME

Developed MBL system is universal. It is compatible with almost analogue sensors. Up to date, the interest is focused to use this MBL system for basic electronics experiments only. It consists of four modules which are Ohm's Law, RC Circuit, Virtual Meter and Diode Characteristic. Capability of this home-made MBL was proven to measure several other physical quantities thus making it suitable for other scientific experiments, just need to change the designed module. So far, this gadget can be attached to all computers with Windows operating system. All provided software applications were calibrated to be compatible with Phidgets analogue voltage and current sensors. Complete MBL system package includes hardware (interface logger) and module software (CD). It uses USB interface for higher-end application.

VI. CONCLUSION & IMPLEMENTATION

This microcomputer-based laboratory (MBL) system is specifically design for Basic Electronics laboratory usage in school and pre-university level. The usage of this gadget in scientific education will promote technical skill and enhance technological innovation and creativity. However, the usage of the interface logger is not limited for mentioned laboratory modules only since it is also compatible with several other physical sensors. Thus, it is also suitable to be applied in physics laboratory with different newly designed laboratory module based on needs and demands in future.

Its portability feature also allows this MBL system being applied in the classroom of schools, or lecture hall at tertiary level for demonstration purposes. In the future, the works will be focus on implementing developed MBL system towards students for the study of its effectiveness. Laboratory manual and spreadsheet will be included within software package as an additional interactive feature. The functionality of the gadget also going to be expands soon with an interactive tutorials and step by step instruction with a mouse click.

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