# Troubleshooting-Based Learning with Interactive Approach for Polytechnics Students

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## Abstract

*Basic electronics experiments are essential in providing fundamental foundation in electronics. Hence, this work proposes an interactive data logger specifically for basic electronics experiments in polytechnics. Development process including hardware and software will be discussed in details. Developed gadget utilizes the microcontroller for voltage measurement and serial communication with computer, Computer software has been designed to represent the data interactively on the computer screen. Furthermore, voltage and current measurement were successfully merged with on-board electronics components for simplified experimental setup. This gadget 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 gadget 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, data logger, interactive laboratory, microcontroller.

## *1. 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 skilled and innovative man power towards future productivity. 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 polytechnics students to sustain their technical skills and techniques since they are expected to fulfil technical know-how job market. Basic electronics experiments cover several subtopics namely voltage-current measurements, Ohm's law, Kirchhoff's law and electrical power concept. 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).

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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). On the other hand, from the research of Haym Kruglak, regarding on current teaching problems in the general physics laboratory shown that equipment, staff, space, staff and student motivation, and avoiding 'cookbook' were the problems most frequently mentioned (Kruglak, 1960). Some proven evidence suggests that the laboratory parts of physics courses at many other schools suffer from similar difficulties (Reif & Mark, 1979). It was clear from the responses that severe laboratory problems in the electronics laboratory are prevalent and are extremely diverse in nature (Kruglak, 1960; 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).

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). To date, there is no reported study on the usage of interactive data logger specifically for polytechnics students taking electrical related courses. Troubleshooting skill has become a must gain skill for almost polytechnics students in Malaysia (Zawawi, 1979). This was due to their future opportunity in seeking job. Most of the polytechnics students were found to become man power in the technical and troubleshooting related job. Hence, this troubleshooting-based learning with interactive approach was to improve students' performance in whether in class of laboratory towards generating more highly skill and quality student to the industry.

## *2. Problem Observing*

A simple study had been done to one of the Polytechnics in Malaysia in order to observe the understanding level of student from the existing teaching method of Basic Electronics classes. Questionnaires were distributed to 176 first year electrical engineering student. It consists of simple comprehension questions on Basic Circuits and some drawing of circuits. They answered the questionnaires based on the knowledge that being teach by their lecturers. From the open-ended questions and the drawings from students, it provide much and extensive information about misunderstanding (White & Gunstone, 1992). Student's feedback answers were analyzed. The total marks achieved from each student were then categorized into percentage according to four groups: understand, misunderstand, no understand, and no answer. **Table 1** below shows the data obtained from the problem study.

From the observation, only almost half out of 176 students get to answer it correctly. The explanations of the answer that been gave by the students were not exactly answer the question. They do not understand the true meaning which the questions needed. Hence they were unable to state the correct answer. 37 percent of them having misunderstanding conception on their answer. Overall, it shows that students facing problem with the existed learning process which causing a lack understanding. This was due to the existed traditional teaching method which was bored and no enjoyable to students. They just take it as a 'must-attend' credit for them to passing the subject.

## *2. System Components*

A 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 (Ibrahim, 2010) 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 (Sookran, Nerik, Vikram, Iskander & Kriftcher, 2006). 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, matriculation centre or even polytechnics to own and maintain it.

Even not a major, but it is one of the factors why our polytechnics still utilizing conventional measurements techniques with traditional apparatus for data collection during experiments. More surprisingly, our surveys found most laboratories in polytechnics were equipped with desktop PC, and only be used for typing, printing and internet browsing. 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 teaching module which enables students to 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 polytechnic's students.

## *3. InterX Development*

The development of this interactive data logger covers hardware and software as illustrated in figure 1. Hardware part consists of the data logger itself, voltage and current sensors. This gadget utilizes microcontroller to digitized analogue input voltage then transmit it using RS232 serial protocol. RS232 protocol was selected based on its good reputation for the last fifteen years and acceptable performance that fit our targeted applications. Microcontroller was pre-programmed so that any changes in voltage level in the range of 0 to 5 VDC at analogue input port are converted. In other words, microcontroller will keep analogue-digital conversion (ADC) and universal synchronous/asynchronous receive/transmit (USART) functions running interchangeably. Software development in our case is the most important part since it will determine how interactive the experiments will be. Technically, developed software will instruct the PC to receive raw data of voltage and current from data logger, processing and display it in the meaningful and interactive way. Furthermore, all instructions and procedures regarding the experiments were integrated to make it more interactive thus function as the instructor. Both hardware and software finally need to be calibrated and tested before going through packaging phase as in **Figure 1**.

### 3.1 Hardware Development

The heart for this data logger is a PIC16F877A microcontroller. Microcontroller is an all-in-one device. For this project, we utilized its analog to digital (ADC) converter as well as universal synchronous/asynchronous receive/transmit (USART) modules.

Precise timing control is done via 20.00001 MHz super precision external crystal oscillator. Reset mechanism consists of 10 kΩ resistor network with push button type switch. Microcontroller is powered by regulated +5VDC from commercially available power adaptor that converted AC supply voltage into regulated 5 VDC. This supply voltage also acts as reference voltage for ADC module of this microcontroller. To avoid small ripple, additional filter was placed using 4.7µF capacitor. Supply voltage for voltage and current sensors also drew from the same supply and sharing the same ground level as reference. Input impedance matching is done through 470 Ωresistors. Microcontroller need to be pre-programmed so that it can run ADC-USART functions as expected. Program was done using BASIC language via mikroBasic compiler from MikroElektronika. Microcontroller was programmed to deliver data at 9600 baud rate. The compiler then generated HEX file and the file was uploaded to the microcontroller using boot loader circuit. Microcontroller only needs to be programmed once. Pre-programmed microcontroller finally was inserted to the data logger circuit.

Microcontroller will generates digitized data at the assigned port with 0-5V logic level. However, this output signal still not compatible with RS232 standard which require 0-12V of logic level. Another interface circuit is required so that precise voltage level can be transmitted to the PC's DB9 port. MC145407 IC functions as a buffer circuit and successfully transmit measured signal from voltage and current sensors to the computer through port 2 (receive) of DB9. Timing for buffer circuit is done by four 22 µF electrolytic capacitors. Finally, data logger circuit was package by placing it in a black plastic container. With universal analogue input, developed data logger was also found to be compatible with several other sensors namely light (Lux), magnetic (Gauss), motion detection and pressure (Newton).

### 3.2. Software Development

Computer programming is done mostly using Microsoft Visual Basic 6 or VB6. Main program or application is InterX LOGGER. Port communication is done using MSComm library with receive baud rate setting also at 9600, identical with transmit rate by data logger. Utilizing many GUI functions such as dialog boxes and buttons, voltage and current measurements were made as easy as a mouse click. This software is able to monitor all data being logged through serial port so that any wrong circuit connections can be detected on the screen. Besides monitoring, InterX LOGGER also functions to indicate whether data logging is performed well by indicating each bit received at the port. User interface of the program is shown in **Figure 2**. This application also contains real-time plotting feature with adjustable vertical and horizontal menu which it can be act as an oscilloscope. Real-time plotting is done using DynaPlot activeX control. Since developed data logger was compatible with different type of sensors other than voltage and current, selection menu was provided at the left side of the program for users to choose which sensor they are using.

Besides InterX LOGGER application, there were two separate computer programs also being developed namely Digital DC Voltmeter and Digital DC Ammeter as shown in **Figure 3**. By default, data logger can only measure DC voltage at maximum of 5 V. For higher voltage measurement, voltage sensor is required. Voltage sensor functions to step-down measured voltage to the maximum level of 5 V, which is compatible with data logger. Current sensor on the other hand converts electrical current changes to DC voltage changes, measureable by the data logger.

## *4. Outcome*

Developed data logger is universal. It is compatible with almost analogue sensors available in the market as shown in **Figure 4**. Up to date, the interest is focused to use this data logger and its software for basic electronics experiments only. Most probably, it will only involve voltage, current and resistance measurements. However, the capability of this home-made gadget was proven to measure several other physical quantities thus making it suitable for other scientific experiments.

So far, this gadget can be attached to all computers with Windows operating system. All provided software applications (InterX LOGGER, Voltmeter and Ammeter) were calibrated to be compatible with Phidgets analogue voltage and current sensors. Complete package includes hardware (gadget) and software (CD). It uses serial port interface and optional USB interface for higher-end application. Gadget with serial port interface has single input channel and maximum channels of eight depending on applications and running with external power supply. However, gadget with USB interface has built-in eight input channels as well as digital input channel without external power supply.

This option was made available since most laptop computers nowadays are not equipped with DB9 serial port. Plug and Play features also successfully applied. Users can start measurements without any driver or software installation.

## *5. Conclusion & Implementation*

This interactive troubleshooting-based learning system is specifically design for basic electronics laboratory usage in polytechnics. The usage of this gadget in scientific education will promote technical skill and enhance technological innovation and creativity. However, the usage is not limited for voltage and current measurements only since it is also compatible with several other physical sensors. Thus, it is also suitable to be applied in physics laboratory. Its portability feature also allows this gadget 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 gadget and software at polytechnics 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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**Table 1: Students' Understanding Level on Basic Electronics Class**

| N = 176 | Percentage of Students (%) |
|---|---|
| Understand | 48 |
| Misunderstand | 37 |
| No Understand | 7 |
| No Response | 8 |

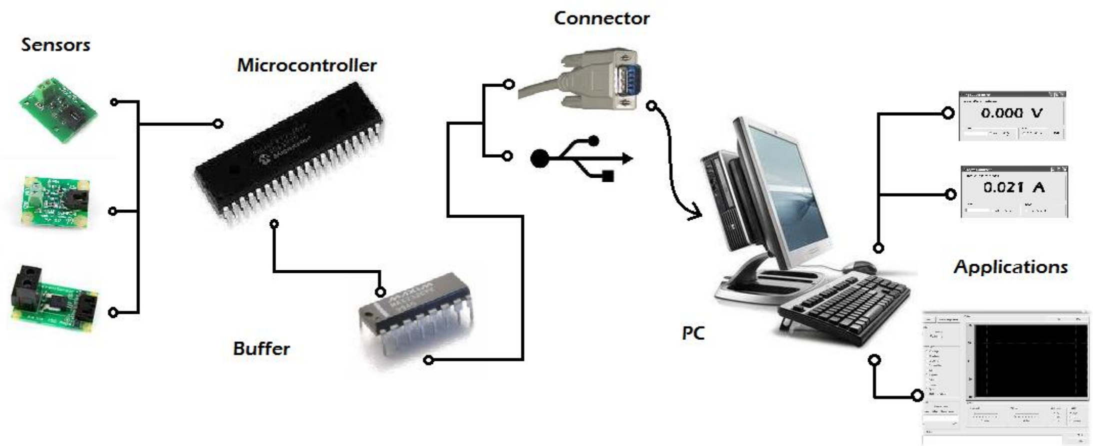


**Figure 1. Project implementation outline.**

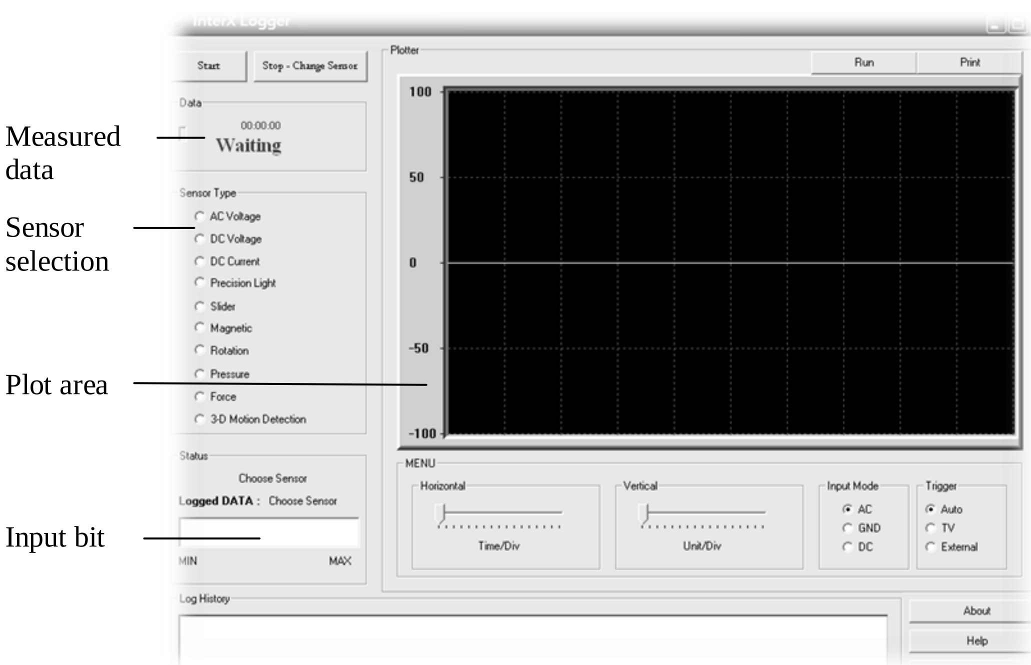


**Figure 2.** InterX logger software.

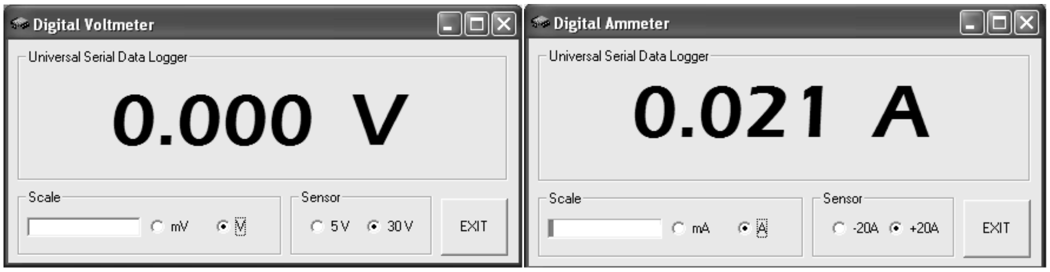


**Figure 3. Digital DC Voltmeter and Digital DC Ammeter.**

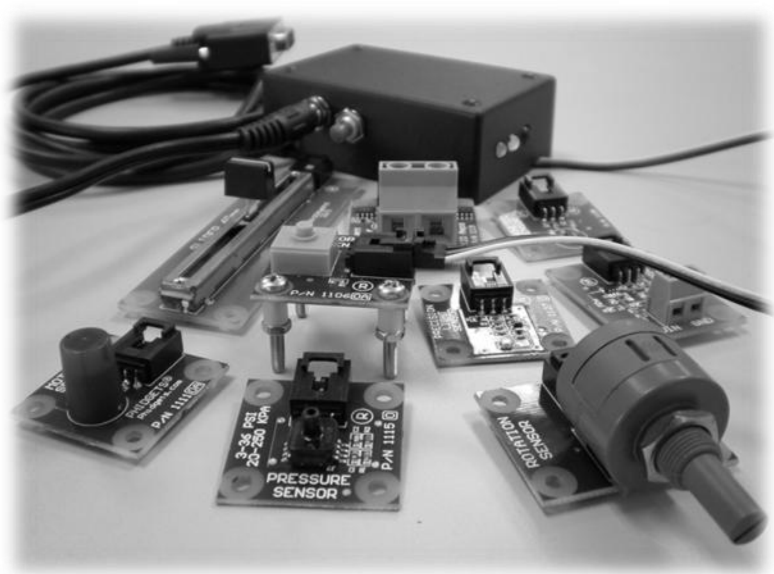


**Figure 4. InterX data logger and various compatible sensors.**