Training Engineers on Complex Transducers Systems

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Abstract: This paper presents techniques and procedures for teaching engineer students to design, construct and control complex systems involving parameters as temperature, pH, dissolved Oxygen, optical density and conductivity of a simulated body fluid form (SBF), which is a widely accepted as a simulation of blood serum. We used laboratory prototypes and developed an e-learning program using Keithley Company’s “Test Point” (versatile software authoring tool available). Training in such complex environments was the object of the laboratory part of the course “Sensors and Technology”. A prototype was constructed to control a cryogenic form to provide a realistic feel of the application. This prototype could possibly be installed in ambulances or other transportation means to achieve hypothermia in human body while transporting critically injured patients to the emergency room. Hypothermia prolongs the transport time of injured patient to the hospital and prevents irreparable damage which often happens upon delays of proper care delivery.

Key Words: Hypothermia, Cryogenic, Sensors, Computer Aided Learning, E-Learning

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1 Introduction

At the Technological Education Institution at Patras Greece senior undergraduate students are educated in the interdisciplinary course “Sensors and Technology”. Typical class sizes involve ninety students. Particular difficulties in the Laboratory part of the aforementioned course arise due to the complex functions and operation of the sensors, as well as because of the variety of specialized and dedicated expensive instrumentation required to perform data acquisition and control. Furthermore, considering the facts that in each two hour session laboratory an average of 12 students are trained, the multiplicity of experimental units becomes a critical factor. It may therefore be concluded that cost, experimental setup, and multiplicity of the experimental exercises are very important factors for the achievement of high quality training.

To meet the goal of high standards education the design and construction of an experimental setup was undertaken. The setup was equipped with the necessary transducers and with all necessary instrumentation in order to collect data and control a cryogenic form. Data collection and processing was achieved by connecting all transducer outputs to a computer system equipped with all modern hardware needed (hardware connected to USB port) for the collection of data. In addition, customized software for the graphic representation and analysis of the data acquired was developed to appropriately control the cryogenic form. It was possible to automatically control cooling and/or heating of the form. To assure students’ understanding and maximum hands on experience a number of “CAL” (Computer Aided Learning) structured instructions was written for every group of transducers which constitutes an integrated self contained entity of the experimental setup. Those structured instructions were used to guide students to perform specific steps in order to take measurements from the Experimental Setup. This approach ensures that students are “learning by doing”.

Furthermore, as the concurrent training of a group of 12 students is not possible, the versatile software authoring tool “Test Point” available from Keithley Instruments (OH, US) was used. Simulations for each one of the above structured instruction sets were developed, thus facilitating off line student training and at the same time giving the students the possibility to use the instruction sets in their own personal computers.

Slight (34°C) or medium hypothermia (30°C) has been proven to reduce the brain’s oxygen demands and has beneficiary neurological results after cases of cardiac arrest [4,5] and injuries [6]. This happens because hypothermia acts on the mechanisms that reduce the consumption of O\textsubscript{2} by brain cells such as:
- Delay of cytotoxic enzyme reactions,
- Reduction in the production of free toxic radicals,
- Protection of the watery state of lipoprotein membranes,
- Reduction of the mesocytic acidosis,
- Biosynthesis, release and engagement of excitatory neurotransmitters.

Hypothermia may also help with emergency neurological cases such as brain trauma, spinal trauma, ischemic encephalic brain incident, hypoarachnoid hemorrhaging, cardio respiratory arrest, hepatic encephalopathy, perinatal asphyxia, hypoxic-anoxic encephalopathy, neonatal encephalopathy [7-8]. It has been reported that hypothermia may help in combating cancer [9], and may also be especially useful in the field of surgery [10-11], as well as in providing first aid in cases of cranioencephalic trauma [12-14].

Considering medical studies on hypothermia, it may be suggested that there is a specific benefit in the provision of first aid if the patient’s body undergoes a situation of hypothermia suppressing and controlling the various biological functions. The transport time, to a hospital or medical center where first aid will be given is thus extended, while minimizing risks.

The experimental setup developed, is primarily focused on the design and construction of an arrangement in which various parameters of a synthetic fluid that simulates body fluids (including blood serum) may be monitored. Through this experimental setup (herefore cryogenic form) we intended to teach the operation of transducers and associated instrument functions in a complex realistic system, in such a way that the end-result is well understood. At the same time “study cases” were developed in an effort to demonstrate the real time operation of various sensors.

3 The Experimental Setup

The developed experimental arrangement is shown in figure 1 and consists of the following:

a) The chamber which has the ability to either freeze or thaw in combination with a properly designed circuit controlling the temperature without moving parts (freeze or heat). The conditions were selected from the computer system. Approximately 300 thermocouples were mounted on an aluminum block to provide the heating or cooling effect. The thermocouples were supplied with positive or negative voltage to produce heat or cold respectively (peltier effect). An electric fan was used for the
uniform distribution of the temperature in the incubator chamber.

b) Properly selected vessel containing the fluid which was simulated body fluid (SBF) [15]. Various sensors were mounted on the top part of this vessel, the output of which was connected into the data acquisition hardware plugged into the USB port so that acquisition of the various measurements was achieved. The vessel with the sensors was located within the controlled temperature chamber. Furthermore a 2 mW He-Ne neon laser was positioned into the chamber in order to illuminate the vessel containing the SBF fluid while from the other side a phototransistor was used to measure the optical density of the fluid thus monitoring SBF degradation through optical density measurements. A number of additional sensors were used to measure conductivity, temperature in various points, pH, oxygen, optical density, and CO2 concentration.

c) Computer system on which measurements are collected from the various transducers. Moreover, the appropriate hardware and software accompanying the various sensors was connected to the computer making data acquisition easier. The system functions were controlled from custom designed and developed software.

4 Education Process and Measurements

In conventional Laboratory courses the outcome is predictable and measurable due to well established methods and procedures. As already mentioned in order to overcome problems arising from lack of multiple experimental units, and from the large number of students trainees three training lab sections were created named:
- Part A
- Part B
- Part C.

The class size was set to 12 students organized in three groups labeled:
- Group A
- Group B
- Group C.

Namely three sub-groups of four students. The total duration of the training time for the laboratory course was set to two hours.

Having in mind the above scheme, 40 minutes were allowed for each sub-group, so that they could be trained in a cyclic mode, each one execute a separate and independent part of the others during the two hours training period.

4.1. Training in Part A

Part A (Fig.2) involves teaching of the necessary theory and analysis of the sensors used to control the cryogenic form, not only as separate parts (individual sensors, amplifiers, signal conditioning data acquisition and transfer into the computer and others), but also as an integrated system as may be seen in Fig.1.

Moreover, real experimental data are collected and stored in files. At the same time, the operation and the anticipated outcome of the cryogenic form are explained. In order to familiarize with the system in which measurements are taken the chemical
composition of the SBF fluid and its use as a blood substitute is presented. Similarities like the fact that both blood plasma and SBF have a constant pH value (practically equal to 7.4) or that both fluids contain dissolved O_2 and CO_2 at specific concentrations. It should also be noted that only a small amount of O_2 and CO_2 gases transferred from the blood are found in the plasma serum. The primary quantities of these gases are transferred from the hemoglobin within the red blood cells. In order for O_2 to go from the lungs to the tissues it is combined with the hemoglobin to form oxyhemoglobin. O_2 to CO_2 exchange occurs in tissues and oxyhemoglobin is formed. When red blood cells contain O_2, their color is red, while when they contain CO_2 the color becomes dark red. The red color is due to the presence of iron in the hemoglobin.

Following the theoretical analysis of physical aspects of the subject, measurements of all variables are taken simultaneously for a time period of about half an hour while the SBF was subjected to heating in the range 30 °C to 37 °C.

4.2. Training in Part B. Building the instrumentation panel

Students in part B are trained to use the graphics oriented authoring tool “Test Point” (Keithley Co.) to design a the necessary instrumentation panel on the computer screen, in which they are taught to collect simulation data, store them in the computer’s hard disk and to produce appropriate graphs. The students build practically the cryogenic form instrumentation, they select and install all required transducers, connect all the electrical wiring or mechanical connections and they use (virtual) instrumentation available from the software. The education flow process is shown in Fig 3.

![Fig.3 Second 40 minutes session of the 2 hour lab course](image)

Using the above simulation CAL software students can be trained without using an actual laboratory.

Techniques developing CAL simulation software have been published elsewhere [16-20]. Building the instrumentation panel with the CAL simulation software, the student is guided by structured instructions to assure that he follows all necessary steps to accomplish the laboratory course. The CAL software is designed not only to inspire the students’ ingenuity and motivation but also to trigger his talent to efficiently use today’s available tools and resources like the internet, electronic Library and other conventional and modern sources in order to execute the required exercise task. In Fig.4 a view of the program’s user interface is shown. In the upper left corner a storage bank of the available sensors, instruments, display organs, and interface units is displayed. In the middle area the selected instrumental display and On-Off Switches are shown, while at the other part the automatically produced code may be seen (upon dragging the icons into the work area).

![Fig.4. Test Point Simulation](image)

4.3. Training in Part C

Next (Fig.5), the student initializes the system and plots the data measurements as a function of temperature so that the results are well comprehended and understood.

In this part students are trained to retrieve data stored in Part A and process them in order to produce graphic curves corresponding to real data acquired from the cryogenic unit. The significance of each curve is then explained to the students.
Fig. 5 Last 40 minutes session of the 2 hour lab course

For example, from the measurements taken, as shown in Fig. 6, pH starts from a value of around 7.64, goes through a maximum around 7.68 for 33°C dropping to the value of 7.54 for 37°C.

The dissolved Oxygen-temperature profiles shown in Fig. 7, show that starting from a value of around 4.5 mg/l for 30°C the concentration is steadily reduced to the value of 3.8 mg/l at 37°C. For the measurement of optical density a light beam produced from a He-Ne laser (633 nm) was used.

The evolution of light intensity curve (Opacity) is presented in Fig. 8.

5. Conclusion

A procedure for teaching laboratory courses related to sensors and their applications were described. To achieve maximum training benefit a real study case of a prototype cryogenic form was developed using a large number of transducers and associated mechanical and electronic components with the associated instrumentation. For in laboratory teaching the cryogenic form system was used in conjunction to graphical simulation application software based on the “test point” authoring tool. This gave the ability to efficiently teach classes of 12 students at the same time using E-learning training. The results of the training venture showed that trained students have achieved higher grades with respect to those trained before (previous years) with other traditional methods. A sample of 450 students was approximately used for a six semester period.

References:


Marios Hatziprokoipiou, Distance Learning as teaching Laboratory supplement, May 25 – 27, 2001, Open University of Patras, Greece.
