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A Study to Improve the Biomedical Instrumentation Lab Training

Abstract- *Constructing and testing the syllabus for experimental laboratory for Biomedical Engineering needs a lot of practical experiences and skills. Especially with the huge challenges and changes happened worldwide in this field of study. The present study discusses the available materials and directions presented up-to-date in the syllabus of the Biomedical Instrumentation Lab (BMIL), and suggest a new hybrid improvement depends on the real requirement for the educational output for the next few years. The object behind this suggestion is to close the gap between the academic university study and the real medical device market, making use the complementary between the governmental and private sector capabilities.*

Keywords- *medical instrumentation, lab training, Medical Lab Training.*

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1. Introduction

Biomedical Engineering Departments have been established for the first time in the Iraqi universities in 1996. In the first five years, the students are accepted to join the department from a different engineering background in the third years after successful in two previous academic years on their departments. Upon these first years, laboratories are classified into engineering and medical laboratories [1].

The Biomedical Instrumentation Lab (BMEL) was one of the medical labs that may be instructed according to the physiologist point of interest such as measuring the electrocardiograph activity of the heart (ECG) or any other vital measurements. The educational outcomes for the graduate students at that time were more close to the clinical works more than technical. This support to close the gap of required skills for the health sector across the country. Especially, with the rapid increase in terminologies and technologies of the medical devices. In the second step, the student started to join the academic studies on the department from the first year other than the third once, and a new touch for the engineering in medical applications are added through courses such as introduction to biomedical engineering in the first year, and so on courses in the other few years. The engineering-wise courses with their lab studies introduce more common engineering sense [2].

Part of the physiological material for the BMEL are excluded and replaced with how to operate and test medical devices. In this stage, the educational outcomes of the graduated student started to improve the technical skills more than the clinical once. The new graduate students this time are more technical and less clinical synchronized with the market required skills. The above two steps build the respective reputation and started to create more challenges against the graduate students and their academic hosts in which they are responsible to simulate the market needs.

2. Biomedical Instrumentation Lab (BMIL) Syllabus

It is not easy to build and test a syllabus for any educational material, especially to know that the BMIL is still a new topic started to be important within the last few years. But at the same time the general syllabus should content the followings:

a) Course description.
b) Course pre-requisites or co-requisites.
c) Course objectives or goals.
d) Course materials.
e) Course grading and policies.
f) Course references or external materials.

In the description of the BMIL, the student will put into practice what they learned through a number of previous courses. The prerequisite materials were mostly the sensors, measurements, and theoretical biomedical instrumentation course. The objective behind this course is to touch, feel and understand the reality of the medical instrumentation with the basic understanding of the design and build of the medical systems.

The course materials depend on many parameters such as the available laboratory equipment (or medical devices) or validation of simulator trainers. Adds to the experience and line of work for the laboratory staff. The course grading is almost divided into three major parts: prelab work, reporting, and post-lab activities. Policies should include the safety regulation, approvals for extraordinary circumstances, and list of priorities. References and extra materials are also assigned by the course instructors for students to support their knowledge and understanding.

3. BMIL Course Material

The material of any educational course was described by the scientific committee of the department, and always this material agrees with the circle of knowledge and required information that should be gained by the students to reach the optimum educational outcomes. All of the above were always affected (especially for lab courses) by circumstances such as the abundance of the equipment in the lab and the instructor and his team base of knowledge. For these reasons, a huge difference was found when checking back the material of the BMIL course for different universities. Studying the syllabus of many of them could finally reach to the following directions of flow:

1st direction: Electronic physics supported by physiological sensing.

2nd direction: Physiological measurement with trainer systems.

3rd direction: Virtual lab training.

4th direction: Real Medical devices training.

Table 1 shows a summary for the first direction of BMIL syllabus [3, 4, 5, and 6]. This direction of the study was related strongly to the reference textbook written by Webster entitled, "Medical Instrumentation, Application and Design" [7].

The chapters in this text reference are written in such sequence that many reference books are written in the same manner but with the modification of the new electronics generation.

Table 1. The summary of the syllabus for the 1st direction (Physiological Sensing)

Description	Notes
Electronic components review.	Review or pre-electronics courses.
Op–Amplifier, and suggestion for different circuit applications.	
Filter design and suggestion for different types of connections.	
Electrocardiography.	Review of physiology courses
Electromyography.	
Electroencephalography or nerve stimulation.	
Measurement of physical quantities such as body temperature or blood pressure and so on.	
Added extra advanced techniques for measurements related to the microcontroller.	

Table 2 shows a summary for the second direction of BMIL syllabus [8, 9 and 10]. This direction of the study was related strongly to the physiological trainer design in the last few years by many companies. The main ideas behind such training are:

- Understanding the electrode(s) position(s).
- How to collect the physiological raw data from the body?
- Real measurement mode shape, value, and adjustments.
- Understanding the clinical collected data post-processing.

Table 2: The summary of the syllabus for the 2nd direction. (Physiological Trainer)

No.	Description	Notes
1	Study of different types of electrodes.	Review or pre physiological courses.
2	Bio-electrical signal measure-ments such as ECG, EMG, etc.	
3	Biomechanical measurements such as respiration, blood pressure, temperature, etc.	
4	Study other advanced application that could be equipped with the trainer such as a defibrillator, plethy-smography, etc.	Advanced topics in physiology.
5	Analysis of recorded signal (mechanical or electrical) and their clinical presentation.	Clinical application.

Table 3 shows a summary for the third direction of BMIL syllabus [11 and 12]. This direction of the study was related strongly to improve the analysis and research skills for the student other than touch and feel skills. It is also important to know that experiments are designed and updated with time according to the last updated clinical state.

Table 4 shows a summary for the fourth direction of BMIL syllabus. This direction of the study was related strongly to improve the practical skills of the students. Such direction of work needs highly skilled instruction board for the lab and also qualified measurement units. The student here will rescue his/her fair from the real medical units and gain good knowledge of troubleshooting and design of systems.

Table 4. The summary of the syllabus for the 4th direction. (Real Medical System)

Description	Notes
Introduction to the real system tools (circuit diagram, mechanical diagram, etc.).	Either get ethical approval for the study of the design of such real systems or study obsolete systems.
A bioelectrical system such as ECG, cautery and so on.	
Mechanical systems such as a ventilator, dental chair and so on.	
Imaging systems such as ultrasound, X-ray and so on.	
Troubleshooting and design notes.	Needs advanced skills from the instruction team.

4. A New Suggestion for Direction of Training

After discussing the previous four directions in presenting the material of the BMIL, and due to the experience of the last 15 years, a suggestion for a syllabus that might be hybrid and more productive is introduced here based on:

i. Take from the first direction the review and principle circuits for the biomedical systems.

ii. Take from the second direction the use of the physiological trainer to test and validate the designed systems.

Table 3: The summary of the syllabus for the 3rd direction. (Virtual LAB)

Description	Notes
Virtual instrumentation description and main features. Data Acquisition Unites (DAQ) advantages, connections, and main functions. Interface programming.	All of these sets are work together.
Analysis tools for the biomedical applications.	Pre and post-processing tools.
Collection of experiments regarding different biosignal or mechanical behavior for clinical use.	Here there is flexibility to build a number of experiments more than that with the other two previous directions.

iii. Take from the third direction the use of the virtual labs to test the initial design of the system.

iv. Take from the fourth direction the practical touches from the real system and try to reflect that back on the new suggested design.

To be productive in the suggested syllabus the following items need to explain:

a. Working Place

The working place is the first step in presenting the new suggestion. Here it is important to prepare more than student lab but a small factory place that for the future, after satisfying the suggested procedure, reach to the product design and sale.

b. Working Material

The working material should also available and presented in the lab. Mostly the required material for the early stages of the project is not more that 3D printer, plastic wires, and sets of electronic components.

c. Logistic requirement

Created idea after pass through the testing and validation needs to register as a patent under an authorized group name. The registration process is the first step forward. This should be followed by the next step in which sending the prototype to the Ministry of Health (MOH) for testing and approve. Finally, after everything is established a marketing plan should be set and reflected back to the lab for an action plan.

d. Final production line:

After finalizing the logistic issues, it is the time to prepare the small factory with their employment (Lab and students) for the production according to request from the logistic for numbers and quantities. The planning and the final production action will be adjusted according to the environmental work conditions.

5. Summary of the Procedure

As an initial summary for the procedure of the work, it is recommended to put in sequence the work as:

1. Win in twin (WIT) project based on make use the good experience skills in the Biomedical Engineering Department (BME) in University of Baghdad with the financial and logistic support of Al – Mustaqbal University College (MCU).
2. The prototyping and the initial evaluation for the product need to be design, test and validate in the BME before started to be logistic work in MCU.
3. The nominated system for the design and product needs to be studied well according to the market needs.
4. The whole story for the final product is:

a. Market study to specify an item for the design.

b. Start the design and test the model by the instruction team in BME to reach to the final beta version of the model.

c. Strat the logistic issue for patent registration and model testing with the MOH.

d. Prepare the required raw materials for the manufacturing and specify the expected number

of manufactured units according to the number of students in the last final years for the two universities.
e. Build the time table and start manufacturing.
f. Testing the final student products needs quality control issues.
g. It is important to add to the production list at least one item per year to reach to a 100% production items in the BMIL.
h. The graduated students how are part of the production lines could be for the future as a freelancer in their living area to take the service calls for future systems support.
i. After releasing the beta version from the designed system there will be another modification and new systems releases, and by this means there is a possibility in the future to build a training center to train the graduated students and any engineers with the new modifications and tools.
j. For the future, a call center for the end user and service engineers needs to be established.

6. Final Conclusions

Win in Twin is a suggestion to improve the syllabus of the BMIL through involving the students in manufacturing a real medical system. After graduation, the student will be the future field engineer for the system that he already was part of the manufacturing process. All of the above will introduce the university as a real partner to the local market and competition with the other worldwide manufactures will improve the teaching skills for the supervisors and students.

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