Introducing educational trends in an undergraduate biomedical engineering laboratory of medical equipment quality assurance

I. LOUKOS, N. KONTODIMOPOULOS, I. VALAIS and I. AVGERINOS
Department of Medical Instrumentation Technology
Technological Educational Institution of Athens
Agiou Spyridonos Str., Egaleo, Athens, 12210
GREECE

Abstract: - This paper presents the design, development and implementation of new teaching methods and materials to enhance the content of the laboratory of medical equipment quality assurance, which is a constituent sector of our undergraduate biomedical engineering curriculum. Activities are performed within the framework of a general project-funded reform, involving the whole program curriculum and emphasis is placed in adhering to current trends in higher education, namely the student-centered approach and the computer-enhanced environment.

Key-Words: - Biomedical engineering education, educational multimedia, medical equipment quality assurance, student-centered learning

1 Introduction*
Currently, higher education is witnessing a rapid transition from teacher-centered to student-centered learning. Within this development, innovative training methods and materials are required to exploit the potential of the new computer enhanced learning environment and also to place the student in the spotlight of this new learning system. This development includes complimentary interactive activities, enabling students to address their particular learning interests and needs and move forward into increasingly complex levels of content to further understand of subject matter [1].

Undergraduate BME education in Greece initiated almost twenty years ago, at the Department of Medical Instrumentation Technology of the Technological Educational Institution of Athens, which, to date, remains the only higher technological education institution in the country offering this specialty. Until that time, even internationally, undergraduate degrees in this field were not very common, with most of the educational activities being research-oriented [2]. In order to comply with educational trends, we are currently in the process of reforming our entire program curriculum and developing new training methods and materials to supplement existing practice. The laboratory of medical equipment quality control assurance, offered in the 6th semester of the program, is one of the eight axons of curriculum reformation.

Reformation is based on the introduction of interactive multimedia-based material in order to supplement laboratory experience and free up classroom time to be used for higher-level activities such as synthesizing, analyzing and discussing more difficult content [3,4].

According to the reformed laboratory’s content, the students will be involved in planning and organizing medical device quality control exercises and, in using test equipment, e.g. patient simulator, electrical safety analyzer, etc. Also, the students will have, at their disposal, a multimedia educational manual, with operating principles, quality assurance and maintenance instructions for certain medical devices.

2 Laboratory Structure
Quality assurance of medical equipment consists of a set of activities, having to do with the evaluation of the provided quality; these usually include a process of selecting, applying and monitoring corrective measures in order to increase productivity, ensure safety, and simplify the equipment maintenance process. An accountable,
systemic approach will ensure that cost-effective, efficacious, safe, and appropriate equipment is available to meet the demands of patient care [5,6].

The laboratory aims mainly to provide in-depth training of undergraduate students in medical equipment quality assurance. A mixed methodology of traditional “hands on” training and supplementary multimedia education of medical devices’ operation and quality control principles is implemented.

The course is structured on sixteen exercises covering the following medical equipment testers:

- Electrical Safety Analyzer
- Patient Simulator
- SpO2 Analyzer
- Defibrillator Analyzer
- Transcutaneous Pacemaker Analyzer

Furthermore the laboratory is equipped with medical devices that are submitted to quality control using the above testers:

- Pulse Oximeter
- External Defibrillator/Patient Monitor
- External Pacemaker
- Ultrasound Unit
- Haemodialysis Unit
- Infant Incubator

The relative theory course provides general background on the subject of quality control in the healthcare environment, focusing mostly on quality control of medical equipment, according to the rules of the ISO 9000 series of standards. During laboratory training, students follow extensive documented instructions to perform a series of measurements. The methodology is based on the utilization of the testers on the medical equipment listed previously to measure certain parameters for each medical device, record the results and compare them to manufacturers’ specifications.

Except for the practical part of the laboratory, there is also a theoretical one. Before performing measurements, students are encouraged to use an existing multimedia educational manual (see Fig. 1), containing the basic principles of operation and quality control of the medical devices. Using texts, figures, pictures, block diagrams and videos, the students are introduced to the basic operation of the medical equipment and also to the basic quality control procedures. In some cases, with the multimedia manual it is possible to simulate, interactively, the operation of the medical devices, before students actually turn them on. Furthermore, the laboratory is equipped with PCs in collaboration with the testers and appropriate software from the manufacturer, which are used to save results and build a relative database.

Fig. 1: Multimedia educational manual front page

3 Educational benefits

Before the reformation of the laboratory content, which is still in process, the traditional teacher-centered environment had as its main focus on the transmission of a body of knowledge from the teacher to the students. The present philosophy of our department’s approach is to train undergraduate students in medical technology instrumentation principles, in accordance with practices implemented in the industry, and driven by the student-centered approach aiming to satisfy student needs [1,4,7]. It encourages students to solve problems they will face in real life as engineers. Student-centered learning environments have an obvious advantage over the traditional teacher-centered environments in that they provide complimentary interactive activities, enabling students to address their particular learning interests and needs and move forward into increasingly complex levels of content to further their understanding of subject matter [1].
With the advent of multimedia computer technology, student-centered learning and instructional technology form a coherent basis for enhanced learning. The computer-enhanced environment facilitates individual construction of knowledge, so that students assume most of the responsibility for their own learning. As in any learning system a human resource (teacher) is required and in our laboratory environment the professors are the ones, who identify and provide access to resources, create problem contexts and refine and extend those contexts to meet identified student needs [8]. Approaching the learning process, as a critical thinker capable of problem solving would enable the student to become a self-centered life-long learner, therefore enhancing his/her qualifications in an increasingly demanding job market [3,4].

Having in mind international trends in education, the emphasis of the reforming process is placed on reorganizing and enhancing the laboratory exercises’ content and particularly, on the training material used and the teaching methods implemented and creating computer-centered laboratory training material, having in mind international trends in education [9]. In this way and according to the work described in this paper, the main addition will be the interactivity with multimedia-based material to supplement laboratory experience. The students have the unique opportunity to deal with new subjects such as designing of medical equipment (e.g. ECG recorders, pulse oximeters), circuit analysis and quality control, re-designing and improvement of available devices and planning and organizing of medical device quality control laboratories.

The application of the proposed educational approach is scheduled for the winter semester of the academic year 2005-2006. Currently, we conduct the Defibrillator Analyzer exercise in real conditions. The exercise consists of two parts; the theoretical and the practical part. In the first part, corresponding to approximately 1/3 of the entire exercise’s duration, the students use the multimedia educational manual in order to study and understand the basic principles of operation and quality control of the defibrillator. At the beginning of the second part, the students attempt to recognize the basic components of the defibrillator unit and the defibrillator analyzer. Following this, the devices are actually switched on. Following extensive documented instructions and according to the quality control principles, the students perform a series of measurements. Using the manufacturer’s appropriate software, they save the results in order to create a database for future comparison of results from different defibrillator devices. Finally, the students must write a report on their work and give their conclusions for the situation of the tested device. This educational scenario, and others to follow, obviously places the students in the spotlight of the learning process compared to the, previously applied, teacher-centered approach. They are challenged to participate in complex interactive activities, requiring increasing levels of intelligence and initiative. The instructors oversee the whole process and maintain an advisory and supportive role.

4 Future directions
The activities described earlier in this paper are the first steps in reforming current methods and materials implemented at our laboratory. The laboratory’s new structure facilitates its future upgrading. Firstly, the set of the testers will be supplemented, with appliances as:

- Ventilator Tester
- External Pacemaker Tester
- ECG/Arrhythmia Simulator
- Fetal Simulator
- Non-Invasive Blood Pressure (NIBP) Analyzer
- Electrosurgical Analyzer
- SpO₂ probe Analyzer

Additionally to the above testers, the laboratory will acquire a complete range of medical equipment for performing the laboratory exercises. Such devices are:

- Ventilator
- Digital NIBP Sphygmomanometer
- Electrosurgical Unit
- Blood Gas Analyzer
- ECG/Arrythmia Simulator
- Foetal Simulator

A future aim is also to carry out an internal evaluation of the methods and materials using the students and instructors as evaluators and completing a questionnaire in order to extract valuable information and useful conclusions for the verification of the above claims, i.e. the educational suitability, in comparison to the traditional used laboratory training environment. The questionnaire will cover the following aspects:

- The educational material
- The equipment
- The software
The instructor
The educational process

This process will help the future improvement of the laboratory’s content, aiming at the most optimal educational usefulness. Keeping that in mind, in the future, quality control of new and used medical devices will be a target for our department, and specialized personnel will be required. The graduates, or last semester students could become involved and the laboratory will be in the position to supply companies, hospitals (public and private) and private medical devices’ owners, with quality assurance certificates.

Finally, the multimedia educational manual has been developed in such a way, to allow for the addition of new data, either for existing devices or for entirely new devices. This ensures the depth and the multi-thematicity of the manual in the future.

5 Conclusions
The medical equipment quality assurance laboratory utilizes a mixed teaching of quality assurance principles, based on traditional “hands on” methodology and computer aided theoretical approach of medical devices’ operation. This combination overcomes the disadvantages of traditional teaching techniques concerning medical equipment quality assurance, improving the laboratory’s educational profile.

The upgraded laboratory perceives biomedical technology as a modern technology with a dynamic development requiring specialized personnel with an overall deep knowledge required for the comprehension of technology and operation of medical devices.

The present work is part of the project “Upgrading of the Undergraduate Curricula of Technological Educational Institution of Athens” (APPS program – T.E.I. of Athens). The learning model used in the present laboratory program, promotes the learning procedure by triggering students’ self-activation, curiosity and participation. It is not supposed to fully overshadow existing traditional teaching methods, but is considered a necessary supplement of these methods. It gives emphasis on student-centered learning, and enhances the traditional teaching methods’ compatibility to today’s international knowledge-driven economy, without sacrificing any of the characteristics that have attracted the local biomedical market to our graduates [10].

References: