



## **Experience of teaching an introductory Biomedical Engineering Course for Undergraduate ECE Students in Pakistan**

**Mr. Ijlal Haider, The University of Lahore**

Ijlal Haider is currently employed at The University of Lahore, Pakistan in Department of Electrical Engineering. He is actively working on Cardiac and Neural Signal Analysis and Interdisciplinary Engineering Education.

**Mr. Farhan Ahmad, UOL**

I am an engineer and fond of doing research in my field as well as bio medical field.

**Mrs. Nishwa Fayyaz, Virtual University, Pakistan**

Nishwa Fayyaz is a graduate student in Bioinformatics at Virtual University, Pakistan. She is also involved in research at Medical Informatics, Control & Signals (MEDICS) Research Lab and Science, Technology & Engineering Education Research (STEER) Network at The University of Lahore as part time research staff.

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## 1 Introduction

In early 20<sup>th</sup> century, Electrical and Mechanical Engineering fields were well established and Medical Sciences were experiencing cutting edge research. However, as research in Medical Sciences progressed, it came across rehabilitating body structures and diagnosing and treating through control and communication signals inside the body. Right at this moment, it started to knock doors of Engineering for the expertise they had in dealing with structures and signals. Since Medical Sciences required assistance from various domains of Engineering, researchers felt need for a new specialized field aiming at bridging the gap between different disciplines. Later, with the advent of modern computing techniques, new avenues of research were opened in Biomedical Engineering which is a merger of traditional engineering and computing disciplines, life science and medicine. At this moment Biomedical Engineering is dealing with as diverse fields as Medical Tribology and Bioinformatics.

This field, however, emerged very late in developing countries. For example in Pakistan first Biomedical Engineering program was offered in early 1990's. The major cause was lack of resources and awareness which eventually resulted in absence of defined career path neither in academia nor in industry. The situation is changing now with a positive rate. However, there still is only a small fraction of students opting for this field in their undergraduate studies. This has posed a challenge to academia to introduce students of different background to this multidisciplinary field. A new introductory course for undergraduate ECE students was needed especially. Several courses are offered at various institutes for non-biomedical students; however a single course covering the breadth of this field without going into depth yet giving essential knowledge to the students was still sought.

In this paper, we have presented our experience of designing and teaching a new introductory course for undergraduate students of Department of Electrical Engineering at The University of Lahore, Pakistan. First, objectives and design basis of the course will be discussed. This will be followed by course details, syllabus, learning and assessment methodology. A survey was conducted among students who enrolled this course from Fall 2012 to Fall 2014 to get their feedback on usefulness of this course. Results of the survey are discussed at the end.

## 2 Objectives and basis of design of the course

Table 1 Prominent areas of Biomedical Engineering pertaining to ECE

Area of Study	Sample Topics
Biomedical Instrumentation	Signal acquisition (EMG, ECG), Measurements
Biomedical Signal Processing/ Analysis	Automated diagnosis of diseases from the signals
Medical Physics	Fundamentals of MRI
Medical Imaging	Medical image acquisition and automated analysis
Bioinformatics	Decoding the molecular chains and patterns
Medical Information Systems/Tele-health	Remote patient monitoring

The main objective of this course was to acquaint students of Electrical Engineering background with Biomedical Engineering. Biomedical Engineering can be subdivided into various areas pertaining to Electrical & Computer Engineering as shown in Table 1. The course was expected to introduce briefly about these areas and strong emphasis on the area of research related to their particular background.

An important factor was the consideration that a graduate with interest in Biomedical Engineering can go for either academia or in industry as both of the areas are well groomed now. The design and development of Biomedical Systems in both directions requires considering several design aspects along with concentrated technical knowledge. To explain this we give several examples to students such as pacemaker batteries cannot be recharged/ replaced every year due to surgical complexity associated with it so it needs to be energy efficient. Figure 2 shows importance of some of the design considerations in sample implantable biomedical systems.

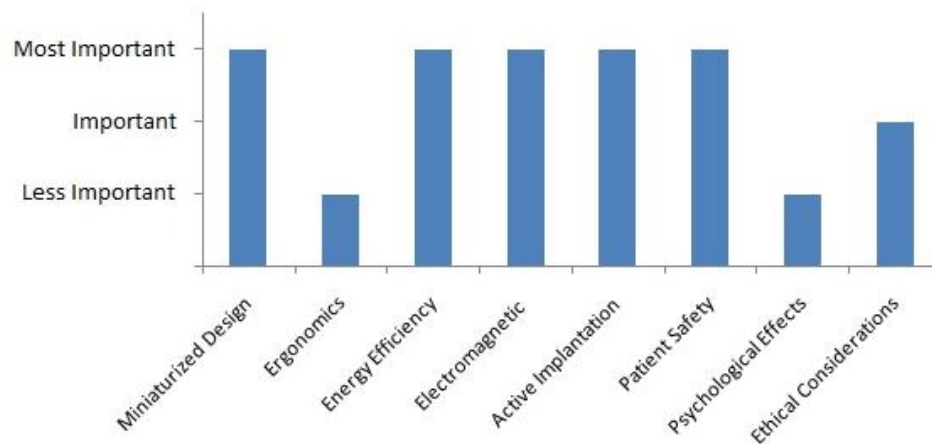


Figure 1. Importance of various design aspects in implantable Medical Engineering design

The course covers several topics related to three focal areas Introduction to Biomedical Engineering, its Application and Designing as per following proportion:

I: Introduction (15%)

II: Application (50%)

○ Diagnostic:

○ Therapy and Rehabilitation:

III: Design (35%)

### 3 Review of literature on the course design

Since teaching of Biomedical Engineering is quite new topic and can be offered at different levels of education, a wide spectrum of topics can be studied under this area. Several authors have presented their ideas and experience in different research articles.

Gibson et al. has developed a teaching pack of Medical Physics for UK secondary schools and discussed advantages of teaching Medical Physics<sup>1</sup>. Robinson<sup>2</sup> has presented their experience of offering an introductory Biomedical Engineering course to students from various backgrounds.

This course was offered as Science, Technology & Society (STS) elective for engineering and non-engineering students. They examined the technological basis of innovation, ethics and economics of medical technology. Ramon has discussed teaching medical instrumentation using MATLAB. They cover several topics including EEG, ECG, Biosensors and Electrodes, Blood flow and MRI<sup>3</sup>. Toft-Nielsen et al. has explained the importance of teaching virtual instrumentation to students of Biomedical Engineering. They have designed a one credit course “LabVIEW Application in Biomedical Engineering” in which students are taught skills in virtual instrumentation for developing biomedical device prototypes<sup>4</sup>.

Multidisciplinary studies require students to take more courses than other traditional courses. This has caused to reduce load of laboratory modules. Beebe has proposed teaching hands on biomedical engineering to the students of biomedical engineering instead of traditional teaching. This will give students an insight into lab work without performing any lab experiments<sup>5</sup>. Ton-Tai Pan has presented design of a myoelectric controlled prosthesis to reinforce mechatronic education offered to Electrical Engineering and Bio-industrial Mechatronic Engineering students at KWIT and NTU in Taiwan<sup>6</sup>. Sodager has presented his experience of a new course on Implantable Biomedical Microsystems offered to graduate students<sup>7</sup>.

LaPlaca et al. proposed and investigated the use of Problem Base Learning for teaching biomedical engineering. PBL is well suited to educating students of multidisciplinary fields such as Biomedical Engineering. They found it effective in graduate programs and based on this they were embarking on introducing PBL for undergraduate courses<sup>8</sup>.

Several other articles were used to conduct study to complete this research such as Rashid's article describing importance of teaching Memristors<sup>9</sup>. Fielder has discussed fundamental issues in designing and teaching of engineering curriculum<sup>10</sup>.

#### 4 Course Information

This course is offered with code and title ECE4552: Medical Electronics in Electrical Engineering Department. The course has 48 hours of instruction spanning over 16 weeks. This is a senior undergraduate course open to senior undergraduate students and masters students as an elective course. Prerequisite courses are Electronic Devices & Circuits, Signal Processing, Instrumentation and High School Biology (one week remedial lectures are planned to overcome this deficiency, in case).

##### 4.1 Course Description

The short introductory description provided to students is as follows:

*“This course provides an introduction to the emerging field of Medical Electronic i.e. application of Electronic System Designing for Medical Applications. These application ranges from diagnosis such as electrophysiological measurement and medical imaging to treatment & rehabilitation techniques such as FES and Prosthesis. This course involves very few concepts in Clinical Diagnosis procedures and Medical Instrumentation. Major emphasis is given to the design of electronic systems for medical application which involves designing for resilience to noise and interference amplifier and filter, electromagnetic compatibility, energy efficiency. Role*

*of signal processing and pattern recognition are highlighted in this course for applications in Cardiac and Neural signals as well.*

*The course will start with Introduction to Medical Electronics. This will be followed by its application in Diagnosis, Treatment & Rehabilitation and appropriate discussion of Medical Electronic design fundamentals.”*

#### 4.2 Study Material

Ample literature is available on this field in the form of Books, Magazines and research articles. Major part of introduction was covered from Medical Physics by J.R. Cameron. For other advanced topics articles from various books, magazines and application notes were referred.

#### 4.3 Course Syllabus

As the course is designed to cover a wide range of topics, we have divided the contents in several modules. Most of the modules are covered in 6 hours spanned over two weeks. Medical Imaging is covered in approximately 9 hours. Major topics covered in the course are shown in Table 2.

Table 2. Major topics of the course and time allocation

Topic(s)	Time given
Scope of Medical Electronics, Diagnosis, Therapy and Rehabilitation, Introductory concepts on basic body function, Bigger Picture	3 hours
Neuromuscular system, Action Potentials, Nerve Conduction Velocity	6 hours
Electrophysiological measurements EMG, EEG, Intro non-traditional measurements EOG, EGaG	6 hours
Neural Stimulation, Evoked Potentials, Prosthesis and Exoskeletons	6 hours
Cardiovascular system, ECG, Parameter Detection	6 hours
Pacemakers, Defibrillators	6 hours
Blood Pressure and Blood Flow Measurements, Plethysmography	6 hours
Medical Imaging (image acquisition & basic processing techniques)	9 hours

#### 4.4 Learning Methodologies

Several other topics were covered by giving short articles to students in their in-class assessments. These articles included Memristors for memory building circuits, digestible telehealth monitoring systems, cognition and perception etc. Two research assignments were given to students in each half of the course. In first research assignment, students were expected to read a given research article, understand it and present it in the class while in other, they had

to prepare a short research proposal on a topic from a list of topics given and submit it to the instructor.

#### 4.5 Course Assessments

The assessment was divided throughout the semester in form of Exams (one semester mid and one semester final), in-class tests, assignments and long research assignments (presentation for one and report for other). The revised Bloom Taxonomy was evaluated to design assessment and teaching<sup>11</sup>. Sessional assessments were designed to be open book to ease the students in remembering the medicine terminology used in the course.

#### 5 Student Survey

The effectiveness of the proposed course structure has been evaluated by feedback of students who attended the course. Quantitative analysis was done in this research by conducting the survey. Students from Fall 2012 to Winter 2015 were asked about the importance of medical electronics course and their experience.

The survey questionnaire was constructed on the same pattern as used by Sodagar<sup>7</sup>. The questionnaire was distributed to the students.

##### 5.1 Survey Results

The questionnaire was distributed online and in print. Survey was participated by approximately 40% of the students. Results of the survey are as follows:

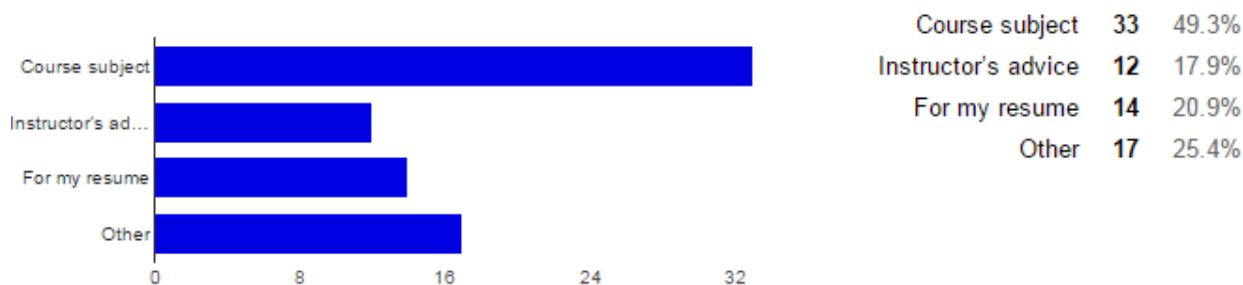


Figure 2. Why did you take the Medical Electronics course?

Approximately 60% of the students took this to use Engineering for help.

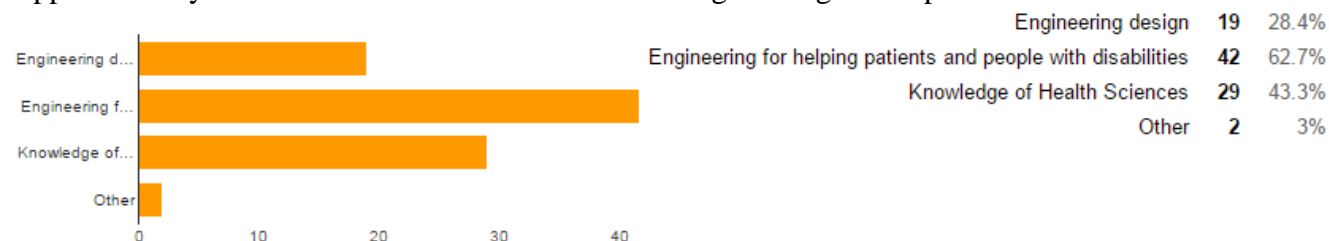


Figure 3. What did you find the most interesting about Medical Electronics course?

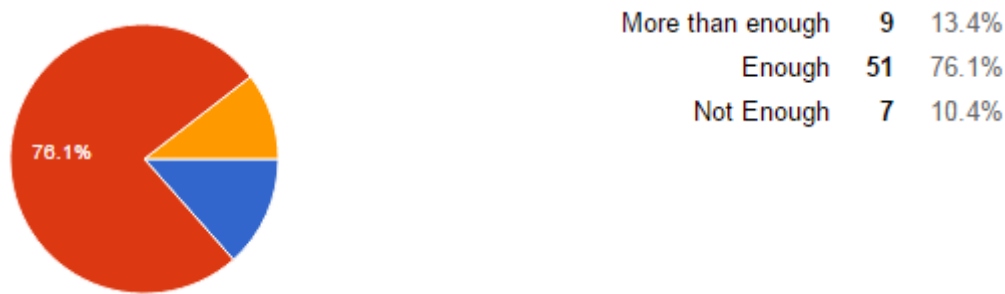


Figure 4. Did the course provide you enough material?



Figure 5. Was this the first time you have taken a multi-disciplinary course?

There were some comments such as “I’m pretty much satisfied with my Job as a starter, because this field is still to be explored in our country, there is huge space for the research and development in this field. I strongly recommend that rather than offering just a single course there must be a complete degree in Bio Medical Engineering/Technology in BS and MS as well.” Whereas majority of the students emphasized to include practical sessions and lab work in the course.

## 6 Conclusion

It was a pleasant experience overall to see positive response from the students. Despite very static academic environment in developing countries, students take interest in multidisciplinary courses designed for direct application in society. The course material and teaching strategy was revised continuously based on student’s feedback. A one credit practical work will be added in the course in future.

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