THEME–5

Effective Use of ICT for Education and Learning

Enactment of Virtual Laboratory for Biomedical Signals and Measurements Course: A Case Study

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ABSTRACT

The signals acquired from the human body is termed as Biomedical Signals. These signals should be measured accurately to determine the homeostasis of the human body. This paper discusses about the outcome of a one credit course offered for third semester for students of Medical Electronics programme, which is taught using virtual laboratory. The outcome of the course was measured by the students' performance in Continuous Internal Evaluation (CIE) and Semester End Examination (SEE). The indirect assessment was using the survey about their experience working with virtual laboratory. The analysis shows that this course is a promising introductory course which also helped the students to learn the basic essence of the key research area viz., Biomedical Signal Processing and Instrumentation and basic requirement of biomedical instrumentation.

Keywords: Virtual Learning, Biomedical Signals, Virtual Laboratory, ICT.

INTRODUCTION

Biomedical Signals

Biomedical signals are the signals which convey some information from the living beings (humans). These signals convey information from different parts of the body which are unique signals of various amplitudes and frequencies. These signals can be as simple as measuring the pulse from the wrist or it can be as complicated as measuring signals which are of microvolts from the brain [1], [2]. There are different types of biomedical signals

- ***Bioelectric signals:*** Bioelectric signals are generated by nerve cells and muscle cells which are originated due to cell membrane which are excited to generate a potential known as action potential. The examples for bioelectric signals are Electrocardiogram (ECG), Electroencephalogram (EEG), etc
- ***Bioacoustic signals:*** Bioacoustic signals are the signals acquired because of sounds generated due to flow of blood, flow of air in the lungs, etc
- ***Biochemical Signals:*** The signals generated due to chemical reactions in the body or samples of the solutions is Biochemical signals. The examples of Biochemical signals are partial pressure of oxygen/ carbon-di-oxide, concentration of various ions, etc.
- ***Biomechanical signals:*** The signals originated due to mechanical activity of biological systems/tissues. These can be measured using motion transducers, pressure transducers, flow transducers, etc. The example for Biomechanical signals are movement of chest walls, etc

- ***Biomagnetic signals:*** The organs such as heart, brain and lungs produce certain week magnetic fields. These magnetic fields are termed as Biomagnetic signals. A typical example of Biomagentic signal is MEG- Magentoencephalogram from brain.
- ***Biooptical signals:*** The signals generated due to optical activity of biological systems either naturally or due to external stimulus is called biooptical signals. For example, measurement of the blood oxygenation may be using reflected or transmitted light.
- ***Bioimpedance signals:*** The impedance shown by different tissues, where one can draw information of blood compositions, distributions, etc is called bioimpedance signals. The typical example is galvanic skin resistance (GSR).

The above signals can be acquired from various sources of signals including eye, brain (nervous system), cardiovascular system, muscular systems, pulmonary systems, etc.

Information and Communication Technologies (ICT) in Education

ICT is used by todays instructors to teach more effectively, to improve the retentive memory of the students. These can be in terms of charts, animations, simulations, pictures, cartoons, etc. Through ICT the teachers can easily explain complex problems to ensure students precise understanding. This makes the class more interactive and more enjoyable, which could improve the attendance and results of the students in the class especially with this Z generation students[3]–[5].

Virtual Laboratory

Virtual laboratories is been developed for usage by students from various disciplines [6]–[8]. The user can be based in anywhere in the world and can access sophisticated equipments in all disciplines and many a times without paying any usage charges. The advantages of virtual lab are

- No investment for major infrastructure enhancement but use the existing computers/laptops at their schools or home
- The students can access anytime and anywhere
- The instructor is not completely required
- Use of sophisticated equipments
- Sharing of resources with different schools nationally and internationally.

The disadvantage observed while using of virtual lab is continuous internet access and availability of power supply which is challenging in developing countries like India. In case the virtual lab is developed using Matlab or LabVIEW which are not open source then the distribution and licensing issue.

There are different types of virtual labs. The important types are animations, simulators and remote triggered experiments. The animations experiments are the one which uses animations to understand the concepts better, where there is not much interactive and user involvement where as in simulators there is requirement of user to input few data and change the findings/graphs or output. In case of remote trigger experiments, the instrument present in the vlab setup the user can change the parameters of the hardware remotely by any authorized user [9], [8].

Virtual Labs in India

Virtual labs is an Initiative of Ministry of Human Resource Development (MHRD) under the National Mission on Education through ICT with an objective of providing remote-access to labs in various disciplines of science and engineering. This labs have web based contents, video lectures, animations, demos, etc. Many IITs and few other universities have developed the contents of the lab in various field of science and engineering (Electronics & Communications, Computer Science & Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Biotechnology and Biomedical Engineering, Civil Engineering, Physical Sciences and Chemical Sciences)[10].

ABOUT THE BIOMEDICAL SIGNALS AND MEASUREMENTS COURSE

The Biomedical signals and measurements course is introduced for the Medical Electronics programme as one credit course with the pattern 0-0-1-0 (**L**-**T**-**P**-**S** – **L**ecture- **T**utorial- **P**ractical-**S**elf-study). The students learnt about the basic biomedical Signals Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Nerve conduction velocity, ECG Pulse missing detector and 12 Lead ECG configuration. These experiments were available with Virtual lab developed by College of Engineering, Pune, India. The details of the above experiments is replicated in Table 1 [11].

Table 1: List of Experiments and Objectives

Sl No	*Experiment Name/ Primary Objective*	*Objectives*
1	To simulate Electrocardiogram Waveform	• To understand normal ECG waveform • To understand noise associated with ECG measurement i.e. line Frequency and baseline wandering • To understand various abnormalities associated with ECG pattern
2	To simulate Electroencephalogram Signal	• To understand normal EEG pattern • To understand various abnormalities associated with EEG • To assist in studying sleep patterns. • To assist in diagnosing mental disorders
3	To simulate Electromyogram Signal	• To understand EMG waveform • To understand noise associated with EMG measurement • To understand how EMG signal is generated from the muscle
4	To simulate Motor Nerve Conduction Velocity	• To simulate the process of measurement of motor conduction velocity (MCV) • To understand the relationship between MCV and various abnormalities associated with muscles • To understand the application of MCV
5	To simulate ECG Pulse missing detector	• To understand various wave complexes involved in ECG analysis • To understand the scheme for measurement of heart rate from ECG • To understand the significance of missing QRS wave and its detection
6	To simulate 12 Lead ECG Signals	• To understand normal 12 lead ECG waveform • To understand various lead selection and their types • To understand various lead color code for ECG

PARTICIPANTS AND TEACHING LEARNING PATTERN

There were 28 undergraduate students who took the course offered in III Semester under graduate, Medical Electronics Programme, B M S College of Engineering, Bengaluru. The semester started in August 2015 and concluded in November 2015.

The students attended total of 12 sessions of virtual labs of 2 hours per week from august 2015 to November 2015. The first laboratory session was for introduction about the course and the virtual lab by the course instructor. The subsequent session was used for explanation of the theory behind each experiment by instructor and then performing the experiment on the computer in virtual lab. The last fifteen minutes was used as discussion session. Each student used to perform the experiments individually. End of each lab the students submitted ten multiple choice questions for the experiments performed by the student and submit it in inpods portal used for assessment. The questions submitted was scrutinized for redundancy and correctness. The final questions after adding few more questions was 1000 multiple choice questions.

For the Continuous internal evaluation (CIE), 1000 questions was uploaded in inpods and randomly 50marks questions were given for the students using the inpods tool for assessment. For Semester End examination (SEE), an internal and external evaluator was present who evaluated for the write up related to the random experiment and the viva questions apart from the multiple choice questions in Inpods.

The only teething trouble was the change of portal of virtual lab in mid of the course which was rectified after consulting College of Engineering, Pune, India[12].

RESULTS AND DISCUSSION

The results of the course are analyzed into two parts viz., Direct assessment and indirect assessment. Direct assessment includes the marks obtained in Continuous Internal Evaluation (CIE) and Semester End Evaluation (SEE). The CIE contains the marks obtained by answering the multiple choice questions for 50marks. This was for

30 minutes. However, the students were given two mock tests for them to practice as Inpods Technology tool was new for the students.

Table 2 and figure 1 gives the details of the students marks scored in CIE, SEE and both combined final result which has 50% of weightage of CIE and SEE which would be used for the grading of the students performance. Table 3 and figure 2 shows the grades obtained by the students. The final grade would be the total (CIE+SEE) and the pattern would be the following:

- S grade – 90 to 100 marks
- A grade – 75 to 89 marks
- B grade – 50 to 74 marks
- C grade – 50 to 59 marks
- D grade – 45 to 59 marks
- E grade – 40 to 44 marks
- F grade – less than 40 marks

It shows that there are no failures (but one absentee) and all of them are having more than 50% of marks and around 40% of the students have scored S grade.

Table 2: Results of 28 Students who had Registered for Biomedical Signals and Measurements Course

Range	*Number of Students*		
	CIE	*SEE*	*Total (CIE+SEE)*
Absent	0	1	1
0–39	0	0	NA
40–44	3	0	0
45–49	0	0	0
50–59	4	0	3
60–74	4	8	7
75–89	9	8	6
90–100	8	11	11
Total	28	28	28

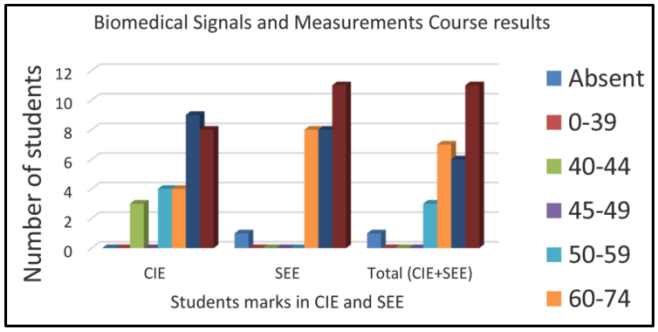


Fig. 1: Graph Depicting the Performance of the Student in Examinations

Table 3: Final Grade of 28 Students who had Registered for Biomedical Signals and Measurements Course

Grade	*S*	*A*	*B*	*C*	*D*	*E*	*F*
Number of Students	11	6	7	3	0	0	1

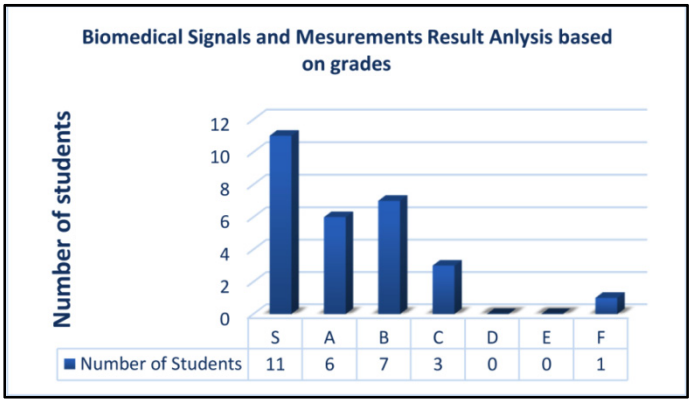
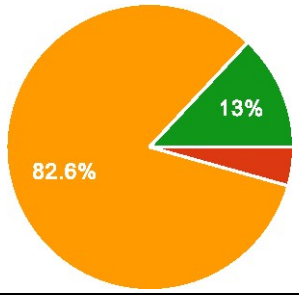
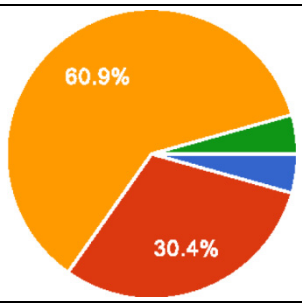
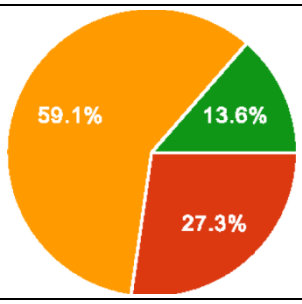


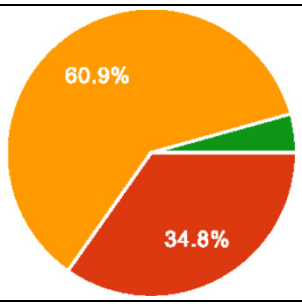
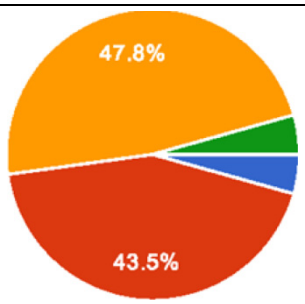
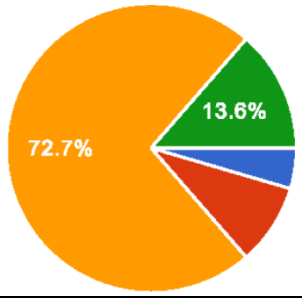
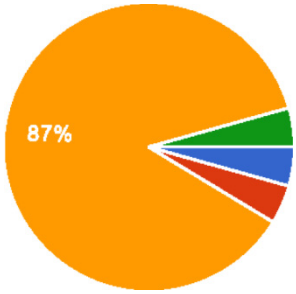
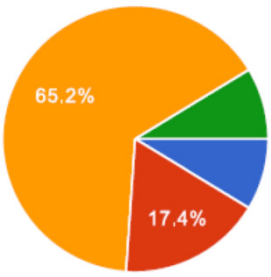
Fig. 2: Graph Depicting the Grading of the Students in the Course

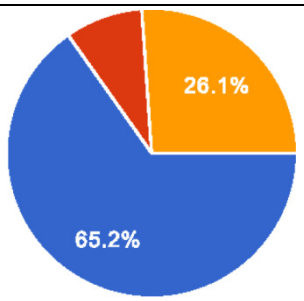
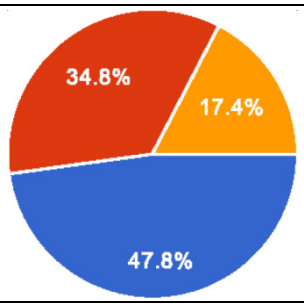
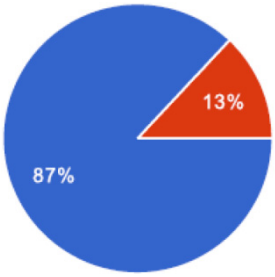
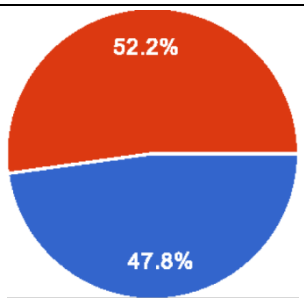
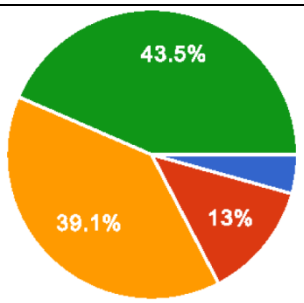
The indirect assessment was done using the question bases survey. This survey was taken after the CIE and SEE to get genuine responses from the participants. Out of 28 students registered, 27 students completed the scores with passing grades and 1 person got Failure grade. Out of 27 students, 23 students answered the survey. The survey was taken in google form and also the analysis was performed using the google form itself. The options are also not in constant order so that students concentrate while answering the survey. Table 4 shows the results of the survey. The color of the graphical representation do not signify anything. The survey resulted that most of the students were on positive side for using virtual lab for this course and they were confident in using virtual lab. Few interesting findings resulted due to this indirect assessment was the following

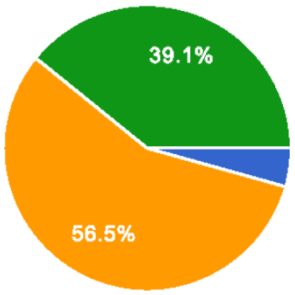
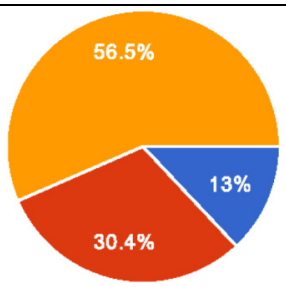
- the students preferred having the instructor for this course
- equal assertive and non-assertive opinion about challenge in performing the experiment in virtual lab
- the students felt that this course is worth 1 credit.

Table 4: The Survey Questions and Results of the Survey

Sl No.	*Survey Question*	*Result*	*Graphical Representation*
1	After using virtual labs, I feel confidence in my ability to understand concepts of the laboratory experiments on my own	Strongly Disagree **0** 0% Disagree **1** 4.3% Agree **19** 82.6% Strongly Agree **3** 13%	
2	How do you rate the online performance of the experiment?	Excellent **1** 4.3% Very Good **7** 30.4% Good **14** 60.9% Average **1** 4.3%	
3	To what degree was the actual lab environment simulated?	Excellent **0** 0% Very Good **6** 27.3% Good **13** 59.1% Average **3** 13.6%	

Sl No.	*Survey Question*	*Result*	*Graphical Representation*
4	Was the measurement and analysis of data easy for you?	Excellent **0** 0% Very Good **8** 34.8% Good **14** 60.9% Average **1** 4.3%	
5	The manuals (writeup, theory & Procedure) were	Excellent **1** 4.3% Very Good **10** 43.5% Good **11** 47.8% Average **1** 4.3%	
6	The results of the experiment were easily interpreted	Strongly Disagree **1** 4.5% Disagree **2** 9.1% Agree **16** 72.7% Strongly Agree **3** 13.6%	
7	A clear understanding of the experiment and related topics was gained	Strongly Disagree **1** 4.3% Disagree **1** 4.3% Agree **20** 87% Strongly Agree **1** 4.3%	
8	You got the feel of a real lab while performing the experiments virtually?	Strongly Disagree **2** 8.7% Disagree **4** 17.4% Agree **15** 65.2% Strongly Agree **2** 8.7%	

Sl No.	*Survey Question*	*Result*	*Graphical Representation*
9	Could you run the experiments smoothly, i.e., without interruptions?	yes **15** 65.2% no **2** 8.7% maybe **6** 26.1%	
10	Do you need instructor for this course?	yes **11** 47.8% no **8** 34.8% maybe **4** 17.4%	
11	Did you follow the step by step procedure before doing the live experiment?	yes **20** 87% no **3** 13%	
12	Do you think performing experiments through virtual labs were more challenging than the real lab?	yes **11** 47.8% no **12** 52.2%	
13	I prefer to take this course online rather than classroom	Strongly Disagree **1** 4.3% Disagree **3** 13% Agree **9** 39.1% Strongly Agree **10** 43.5%	

Sl No.	*Survey Question*	*Result*	*Graphical Representation*
14	Experiments in the course are sufficient for one credit	Strongly Disagree **1** 4.3% Disagree **0** 0% Agree **13** 56.5% Strongly Agree **9** 39.1%	
15	Rate your overall experience of the course	Excellent **3** 13% Very Good 7 30.4% Good **13** 56.5% Average **0** 0%	

CONCLUSION

The biomedical signals and measurements course was offered to the students of III Semester medical electronics programme at BMS College of Engineering, Bengaluru India. This course was a practical course using virtual lab developed by College of Engineering, Pune, India. There were 28 students who registered for the course and 27 students completed with passing grades. The assessment was both direct (exam based: CIE+SEE) and indirect assessment (online survey). The direct assessment shows that there are no failures (but one absentee) and all of them are having more than 50% of marks and around 40% of the students have scored S grade. The indirect assessment shows that most of the students are on positive side for using virtual but there may be requirement of course instructor and the course is sufficient for one credit course. Hence, we can use virtual labs and ICT for effective teaching and learning.

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