“Engineering is Fun” - in the Instrumentation Laboratory

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Abstract. At the Department of Electrical and Electronic Engineering at the University of Miskolc in average 200 students per semester have 2 hours per week practice at the Laboratory of Measurement Technologies. Motivation of the students is decreasing from year to year, as well their basic knowledge in electronics is very low. Teaching should be started at very basics and finished with the most sophisticated measurement technologies, therefore besides of “What to teach?”, the question of “How to teach?” is became one of the most important questions of today’s education. We aim to work out practical experiments close to student’s everyday life in order to increase students’ motivation.

In the paper teaching method development in the field of instrumentation is described. Traditional sensor problems defined by new approach are introduced, student solutions are shown. Course of “Test and Diagnostic” running in final year of study for electrical engineering students includes project based practices, which are also described in the paper.

1. Introduction

Students regularly come to lectures, listen the actual presentation with both ears, think about it and ask questions, than they are keen on coming to the laboratory to try in practice all those theoretical knowledge they picked up at the lectures, and they do not want to leave the laboratory at the end of the training hours…this is the dream of the most of professors. The reality at our university, and presumably at many other universities also, is slightly different from the above described one. Students have many different activities over their studies, they have job, they have Internet, they have different meetings, etc. Even if they spend their time useful, their interest in compulsory university subjects getting worse from year to year. From the other side, ratio of the people in the age-group studying at higher education is dramatically increased in the last 18 years in Hungary (from 10% to 48%) which has also negative effect to the student’s professional calling.

Department of Electrical and Electronic Engineering besides of many other subjects teaches metrology, measurement technology, instrumentation on different levels and at different engineering courses, like mechanical engineering, information engineering, electrical engineering. In average 200 students per semester come to the laboratories of the department for 2 hours per week training, which means that for example load of the Laboratory of Instrumentation is 24 hours per semester in average with 16 students per group. While 10 years ago we should emphasize only professional points of a subject, i.e. we had to decide only what to teach, today we must concentrate to the problem of “How to teach”, to make students active and to make them to learn theory and practice of the subject. Today’s students should much more than before understand what’s the use of a knowledge and if they can find linking between the laboratory practice and their real life they can enjoy the actual activity. On the above reasons our teaching team has entirely reworked the practical program of the courses listed.
above. New experiments are worked out and implemented into our education, mostly in teaching computer controlled measurement systems.

| Semester | 1. Semester | 2. Semester | 3. Semester | 4. Semester | 5. Semester | 6. Semester | 7. Semester |
|----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Contact  | 1           | 2           | 3           | 4           | 5           | 6           | 7           |
| hours    | 1           | 2           | 3           | 4           | 5           | 6           | 7           |

- Basic courses in Natural Sciences (math, physics, material sciences, etc.)
- DAQ sensors: 0+3 hours
- Courses in electrical engineering sciences
- DAQ: 1+2 hours
- Courses in specialized engineering disciplines including the final year project
- Courses in economics and management
- Other courses (human, language, sport)

Figure 1. Educational plan of BSc Electrical Engineering course at the UM

On the figure 1, the course plan of the BSc level electrical engineering course is shown. Dark (red) fields show contact lessons and practices in measurement technology related subjects.

Final year electrical engineering students have course in “Test and Diagnostics”, in framework of which we introduced a special project based practice. Students work in 4-5 persons team, they define the task, divide the work between each other, study necessary theories, realise the project and finally divide the summarized score between each other. A working result must be presented at the end of the semester.

2. Same Task – New approach

Practical training in computer controlled instrumentation courses includes study of sensors and data acquisition (DAQ) equipment, as well as study of software development systems, like LabView or Labwindows CVI. Students build sensing circuits, connect them to computer through a DAQ device, develop measurement controlling software and also some data processing and analyzing software [1].
By our experiences the problem definition is a cardinal point in student motivation. We can draft the same training task by different approaches.

The following two definitions are equal in practical aspect:

1. Build a vibration sensing circuit using “xxx” type piezoelectric accelerometer and charge amplifier. Develop measuring software suitable for continuous data acquisition and signal display. Using FFT analysis define frequency spectrum of the vibration signal.

or

2. Built a sensing circuit and develop measuring and analysing software suitable for display your mobile phone call-vibration time graph and to define frequency of the highest amplitude component in the mobile’s vibration signal.

In the tasks, described above students had to solve the absolutely same hardware and software problems, difference was only in the definition of the problem. In the first example we gave more scientific description of the task but did not defined the practical use and application exactly, while in the second point we only gave students an application example, which is the part their everyday life (mobile vibrates in our pocket quite often). First drafting requires a creative student who can realize why it is useful and what is the interesting in the task. Students solving the problem drafted in point 2, get ready the application example, but they were really happy with the training, and much more successful. They were motivated for thinking, and they developed more creative, scenic and usable applications.

3. New practical experiments in the laboratory
The other problem our teaching staff faced is the insufficient fundamental knowledge of non-electrical engineering students in electrical engineering and electronic disciplines, which makes even more complicated to find attractive and useful at the same time tasks for them.

In this academic year we tried to create new and encouraging tasks for students and we entirely reworked the practical program of the course. Here some examples from our development work are presented.

3.1. Measurement and analysis of the mobile-phone’s vibration
This practical experience, mentioned also in the previous section, includes investigation of the vibration sensors, and practical use of the FFT analysis [3]. In this experience students have to built the sensing circuit and develop a measurement control and data analyzing software.

Figure 2. Measurement of the mobile-phone vibration-call by a piezo-electric accelerometer
By our experience students really enjoyed the task including the following details:

- The program developed by the students measures the phone vibration by a piezo-electric accelerometer in a user defined time interval and by the user defined sample rate.
- Display acquired data on an acceleration-time graph.
- Set two cursors on the graph. The user can move these cursors.
- The program analyses the signal between cursors with FFT analysis. The user can apply windowing function to the signal to be analysed if he/she decides. The windowing functions can be chosen from a list.
- Plot frequency spectrum on an amplitude-frequency graph.
- The program selects the three frequency components with highest amplitudes and displays these frequencies on the user interface window.

Figure 3. Student solution of the mobile phone vibration measurement (user interface)
3.2. Measurements using capacitor microphone

Practical tasks using a capacitor microphone were also very popular among students. In this task students have to connect a simple capacity microphone circuit to the data acquisition board, to develop on-line sound measurement controlling software with on-line frequency analysis. The program has to display the voice time and frequency graphs, and to define the frequency of the sound with highest amplitude. The program also has to define the difference between the measured voice and normal A-voice (440Hz) frequencies. With small modifications of the task students can use different indicators, LEDs to show voices parameters and levels, etc. This practical experiment made students interested not only in measurement technology, but also in electronics, as they see the very simple electronic circuit, and also in data analysis (FFT).

![Diagram of capacitor microphone circuit]

Figure 4. Student solution of the sound measurement and analysis
The figure 4 shows that we can’t expect from students a perfect program with elegant surface design because time of practises is short, nevertheless the functionality of the programs is usually good.

3.3. Measurement with laser distance sensor
The “laser” is a magic word for students. Interesting, that the word itself already motivate students, even without knowing the exact problem to solve. To keep their interest on high level we should work out encouraging experiments [2].

In one of the experiments we put a small wheel in front of the laser sensor. The goal of the task is to find out beat of the wheel. Our measurement cards have got analogue output and digital input/output. So in this task analogue output also can be used. With some changes a surface measurement or recognition can be also introduced into practice.

4. Project based courses in engineering education
Students of BSc level electrical engineering branch have the course called “Test and Diagnostics” in the very last semester of their studies. This is the time when they already have finished basic and professional courses and they work on the final degree project. In this semester we decided not to add much to their theoretical knowledge, but to increase their practical experiences and to provide possibility for team working. The course was very successful, students enjoyed working on real problems. Same subject runs in the second semester of the MSc level mechanical engineering course, therefore in this academic year as an experiment we made mixed teams with electrical and mechanical engineering students. Details of this course and the first experiences are shown below.

4.1. Structure of the course

Week 1: Forming of teams including 4-5 students, informing students about the possibilities and requirements. During the following week each student has to work out a proposal for a project which he/she suggest to his/her team for realization. The only requirement, that the project must include some computerised test and diagnostic part, and the project has to be realized by the end of the semester. Each team will work out one project during the semester, selected by the teacher from the given team member’s proposals.

Week 2: All the students bring a project proposal and get 5 minutes to introduce the goal of his/her project, concept of team working, division of tasks, time schedule. Teacher selects one project for each teams from submissions. The selected project should be worked out by the team. The student, whose project is selected for development, automatically becomes to leader of that team.

Week 3: Leader of the team presents the plan of the work, defines tasks for each team members, defines time schedule, deadlines, etc.

Week 4-9: Development work. The teacher and technicians of the department provide necessary help in this period.

Week 10: Presentations of the projects in 15-20 minutes each. The whole student group listen presentations, ask questions, take part in the discussion, etc. After the presentation and questions the teacher evaluates the project solving and defines a summarised score for the team. The maximum score for a team is 5 times the number of team members. Students of the team have to divide the score between each other themselves, the result will the final mark of each students.
4.2. Experiences of the first year

1. When students were offered to form teams themselves, they automatically made groups by their study efficiency. Good students went to one group and the less efficient in the studies students also stayed together in an other group. This solution resulted very unbalanced groups, expectedly far from each other in success. We decided to mix students to have good and not so good students also in one team. So we moved unbalancing inside of teams, where tasks were defined for persons. As the teams in whole were interested in success, they had to find task for each member to make him/her successful.

2. In many cases (at about half of the students) project proposals included too much complicated or time-requiring task. It means that these students could not realize the complexity of the project or esteem how much time they will need to solve a problem.

3. Students really enjoyed this work, they have spent more time in the laboratory than the 4 hours compulsory schedule. Electrical engineering students liked not only electrical and electronic tasks but also they did not mind to drill or saw and make other mechanical works.

4. Self-evaluation of students was really fair except of one team, where the laziest student having the loudest and determining character, drastically pressed for much higher mark than his achievement would deserve.

5. Half of the projects theme was connected to the team leader’s final degree project, so results of these team works were included into the leader student’s degree project. It means, students tried to define proposals from that professional area where they are familiar and work in, and the results were also usefully utilized.

Figure 5. shows an example from the students projects. The team has developed an automatic window shutter system controlled by light intensity.

Figure 5. Windows shutter control system with light sensor (student project)
5. Motivation through the Internet
The team of the department has developed a remote controlled laboratory open for all through the Internet. The laboratory is not secured by password, it is absolutely free for every Internet users. All what a user needs a web-browser. The system has special safety solutions in order to avoid injury of the real equipment by Internet users.

The system includes 3 demonstrative measurements: testing a linear displacement sensor, testing power LEDs and testing a small DC motor. The user can control movement of the displacement sensor’s actuator, control voltages of three different colours power LEDs, set motor rotation or motor load. While controlling experiment different parameters are measured, including voltage, current, power, temperature, light intensity or rotational speed. Analogue input, analogue output, counter/timer, digital I/O and relay modules are used in the system for control and measurement.

In addition to the virtual surface, tests can also be observed on a webcam installed onto a stepper motor. Selecting an experiment by the user, the webcam automatically turns to that experiment. Power supply of the laboratory has also a special solution, because using the GPIB controlled power supply and DIO lines of a data acquisition board the power supply switches on the laboratory when a user enters and switches off it when the user leaves the laboratory.

The laboratory is developed and implemented by students of the department. English and Hungarian version of the laboratory is available.

The remote controllable laboratory serves the blended education from one side and teaches students for up to date industrial control and measurement methods from the other. In this “virtual” laboratory students or other Internet users are not only simple lookers-on of the measurement results, but they are active stakeholders of the system who can control movement, rotation or light intensity.

6. Conclusions
Course of computerized instrumentation is a practice oriented subject, which requires activity and creativity of students. New practical experiments worked out at our department encourage students, increase their motivation. One only problem we still have with these new experiments, that students meet these problems close to the end of the semester, when we are finishing working with them. The practical training has to be started by study of the development system (LabView or CVI), and followed by study of data acquisition and only after these introductory we can start with new and more interesting experiments. So the main question of the future is how to motivate students from the very beginning of the semester.

7. References
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