

ON THE WAY FOR A BETTER METHODOLOGY IN TEACHING/LEARNING INSTRUMENTATION FOR MEASUREMENTS AT MECHANICAL ENGINEERING COMPULSORY SYLLABUS

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Abstract — *Instrumentation for Measurements is a course of 3rd year, 2nd semester, in the 5-year Mechanical Engineering degree, run at Faculty of Engineering of University of Porto (FEUP) under the responsibility of the first author, in which around 60% of the time is devoted to 'hands on' laboratory activity, involving a large number of students.*

The teachers' team of this course has a broad range curricular training, not only in their different degrees but also in several post graduate fields of specialisation. This brings a transversal perspective, which is very important when dealing with the teaching/learning of multidisciplinary matters.

Continuous (theoretical and experimental) assessment has been used during the last 4 years. It has been carefully planned and programmed at the very beginning of the semester, exploring different student capabilities, either individually or in group.

This paper presents the methodologies that were used and comments their advantages and disadvantages.

Index Terms — *Teaching/learning methodologies, hands on laboratory, continuous assessment, experimental training.*

INTRODUCTION

During the 5-year degree in Mechanical Engineering at FEUP, early experimental training on instrumentation for engineering measurements appears at the 3rd year, 2nd semester in the 'Instrumentation for Measurements' course.

This is the third course offering the students a true 'hands on' laboratory experience, following two others on 'Electricity and Electronics' and 'Digital Systems'.

Around 60% of the time is devoted to 'hands on' laboratory activity involving roughly 130 students. On the lab, students are supposed to have confirmatory practices of laws, effects and characteristics of many measuring devices associated with their typical signal conditioning circuits. Also, they should get a good familiarity with equipment (of laboratorial and/or industrial type), measurement procedures and methodologies, covering an extensive range of physical

quantities and metrology concepts of interest in the mechanical engineering field.

Complementing the main goals referred above, the course also promotes students' teamwork skills, personal responsibility and criticism, through the preparation of lab activities, short presentations and reports, as well as exercising their self-organizing, conflict-solving capabilities and, if possible, implementing some practice in self 'learning-through-teaching'. Nowadays, these goals are among those recognized as being of great importance in students training for their future engineering environment, [1, 2]. The following sections will describe some aspects of contents and classes, the assessment methodology and results during the last 4 years. At last, comments from some students and from the school's psychologist are listed.

CONTENTS AND CLASSES

This discipline is based on theoretical (1h30/week) and lab (2h30/week) sessions.

Theoretical sessions are planned to make concepts and principles understandable; to convey some of the topics of theoretical syllabus; to discuss and analyse some typical problems; to perform some simple demonstration either using simple devices, video clips, simulations and animations; to discuss some technological constructive solutions and their main characteristics. One short e-learning module in 'Strain Measurements' is available [3].

In the lab sessions (12 modules along the semester) students are organized in four work groups of three fixed elements.

All the theoretical and experimentally guided information, complemented with several animations and simulations, is supplied on the first lab session in an interactive multimedia CD-Rom, [4].

The main experimental tasks are focused on confirming sensors/transducers working principles, determining their characteristics and associated measured parameters (sensitivity, resolution, linearity, stability, hysteresis, etc) and their relations with manufactures data. Some calibration procedures are made, allowing students to get real experience with equipment usability and their limitations.

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The use of data acquisition systems is an early practice. Yet, along several tasks, students are face to face with calculation of the measurements' uncertainties, which is of a tremendous importance but, generally, strongly persecuted by them.

In lab sessions the main relevant actions are: the manipulation of equipment and devices used for experimental proposed tasks; the development of students' capacity in analysing, interpreting, criticising and reporting their experimental results; the exercise and promotion of group activities skills (decisions, planning tasks, application of acquired knowledge, conflict solving, group presentations, ...).

A constant and strong attempt is focused on making the students active participants instead of passive observers. Therefore, the training staff is permanently alert to expand students' perspectives as much as possible, either motivating any student's personal request in extra curriculum problems [5] or in finding ways of turning closed problems in, somehow, 'open-ended' ones [6]. Also, the staff is constantly asking questions about related concepts and methodologies, requesting very short presentations and reports, forcing the discussions and criticism among groups, based on their final results, conclusions and used strategies.

ASSESSMENT METHODS

This discipline has a continuous assessment of the theoretical concepts and experimental procedures and methodologies. The continuous assessment is performed during lab sessions. All the assessment criteria are available to students from the beginning of the semester through the web page of the discipline [7]. Namely, the web page provides the assessment's types and their weights in the student's final mark, as well as assessment's timetable and marking grids.

Table I presents the different assessment sorts used in this discipline during its four years of running.

TABLE I
ASSESSMENT METHODS

METHODS	1999/00	2000/01	2001/02	2002/03
GROUP LAB PERFORMANCE	40%	30%	30%	15%
WRITTEN TESTS	30%	40%	40%	40%
REPORT	10%	10%	10%	---
POSTER	10%	10%	10%	25%
PRESENTATION	10%	10%	10%	---
LAB TEST	---	---	---	20%

In the school year 2002/2003 a turnover took place in terms of assessment components. Up to 2001/02, group assessment weighted more than the individual assessment – see Table II. However, this weighting led very often to situations where bad students supported themselves

excessively in the group and, on the other hand, good students were delayed by the group. In other words, the high group component weight tended to average out student's differences.

TABLE II
INDIVIDUAL AND GROUP ASSESSMENT

	99 / 00	00 / 01	01 / 02	02 / 03
INDIVIDUAL ASSESSMENT	30%	40%	40%	60%
GROUP ASSESSMENT	70%	60%	60%	40%

This turnover also vanished two of the components implemented since the beginning: a final report focused on one of the experimental tasks (chosen by each student's group) and its complementary presentation. The 10 minutes presentation (where one element of student's group was selected just before the presentation beginning) has revealed, very often, important lacks of knowledge in the learning matters, not only in the presentation subject itself but also in related matters.

Another reason for suppressing the component based on the final report came from the fact that students used multiple and nowadays easily available sources of information, without being judicious. Plagiarism from Internet fonts [8] is a real problem detected all over the world and has been object of reflection. So, some tools have been developed for detecting fonts of information, as is the case of the Turnitin software (www.turnitin.com). Therefore it was believed that this assessment type should be left for later courses in students' syllabus, when student's maturity is more developed.

These considerations associated with the high experimental content of the course led the staff to decide that an oral and individual examination component should be established, even if difficult to implement due to its inherent high time consuming.

During last school year experience, the students' lab performance (personal and group efficiency and knowledge) contributed 15% to the final mark. The results from individual performance in written tests along the semester (one of multiple choice type and two of traditional problem solving type), had an individual contribution to the final mark of 40%. A poster based on one chosen theme (among several defined in the beginning of the semester) was a complementary group assessment strategy weighting 25%. Finally, during the last lab session an oral and individual examination of 20 minutes was performed, in order to test laboratory skills and related theoretical concepts.

SOME RESULTS

The final results of the discipline during those 4 years are presented in figure 1.

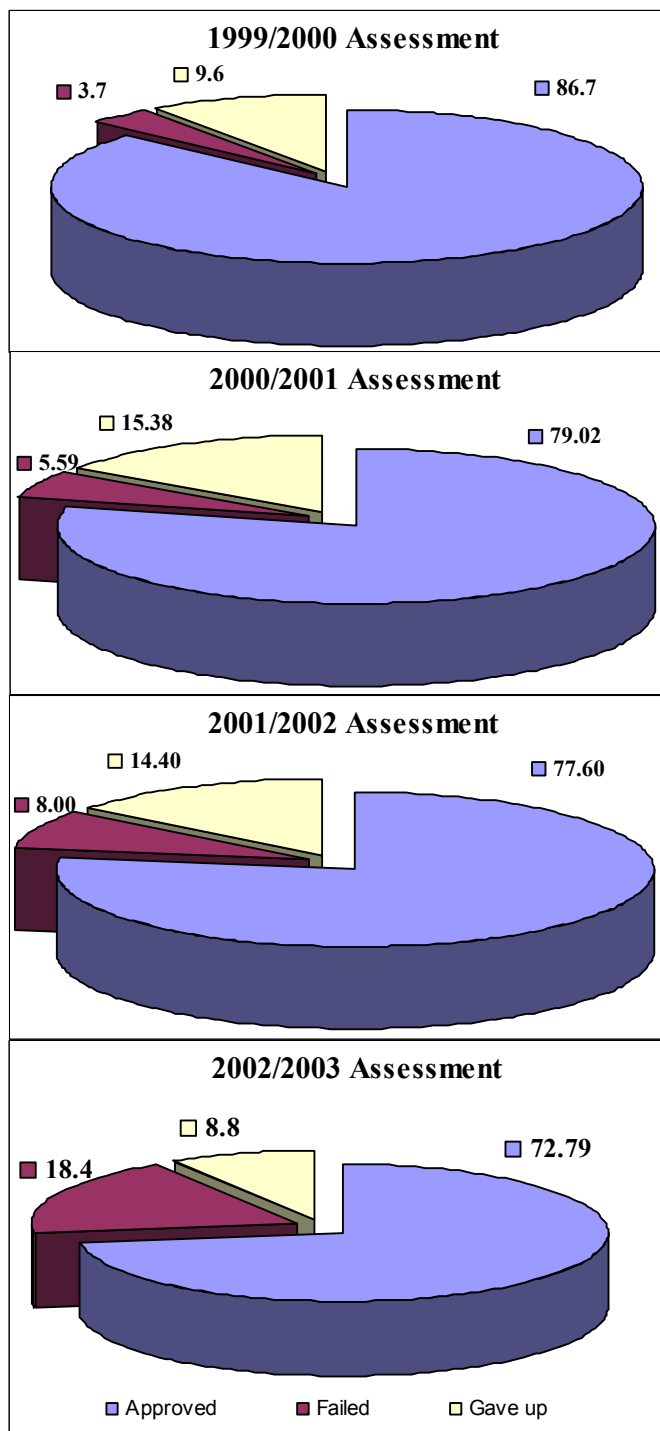


FIGURE 1
FINAL ASSESSMENT SINCE 1999 TO 2003

In the school year 1999/2000, students were imposed a maximum number of missed lectures, of either lab or theoretical type. In 2002/2003 this condition was compulsory only to lab sessions. Also, in this school year it was required a minimum mark of 9,5 (out of 20) in both written tests and

lab evaluation components. These conditions brought down the 'gave up' students (students not finishing all the different assessment components) to approximately the same value of 1999/2000. However, the number of 'Failed' students increased by five times – see Table III, probably as a consequence of the increase in the individual component.

TABLE III
ASSESSMENT, CONSTRAINS AND RESULTS

	1999 2000	2000 2001	2001 2002	2002 2003
INDIVIDUAL COMPONENT (%)	30	40	40	60
GROUP COMPONENT (%)	70	60	60	40
LIMITED MISSING THEORETICAL LECTURES	YES	No	No	No
LIMITED MISSING LAB LECTURES	YES	YES	YES	YES
MINIMUM MARK AT WRITTEN TEST AND LAB COMPONENTS	No	No	No	YES
GAVE UP STUDENTS (%)	9,6	15,4	14,4	8,8
FAILED STUDENTS (%)	3,7	5,6	8,0	18,4
APPROVED STUDENTS (%)	86,7	79,0	77,6	72,8

The school years of 2000/2001 and 2001/2002, in which the only constraint to the students was the limited number of missed lab lectures, complemented with a raise of 10% in the individual component and a drop of 10% in the group component, the number of approved students has been nearly of same order while the number of 'Gave up students' nearly doubled when compared with the two other years.

From these experiences, the staff team believes that at this level of student's maturity and when using a continuous assessment methodology, it is very important to establish a policy that simultaneously imposes:

- a maximum number of missed lectures;
- a minimum mark in written tests and lab evaluation;
- individual assessment component higher than group component.

In fact, the staff team believes that the student's skill all over the learned matters was significantly improved when these features were imposed during 2003/2003.

FINAL COMMENTS

During the last school year (2002/2003) several points of view have been discussed with the school's psychologist trying to get some more sensitivity in the evaluation of all

these pedagogical experiments. It was decided to submit the discipline to a final appraisal by the students, during the last theoretical session in which the staff team was supported and, in a certain way, guided by the school's psychologist. It will be registered in the following periods her general comments as well as some students' comments, inquired purposely to be included in this work.

The main school's psychologist conclusions were:

- (i) The strong interaction between theory and laboratory practice, as well as the depth of required student involvement in classes, constitutes a strong and wide learning base, not only of the nuclear but also of other general skills.
- (ii) The diversity of information resources divided students opinion. Most of them perceived it as something positive but some of them said it could lead to some type of 'information overload' and loss of focus [9].
- (iii) Students are still too much oriented into exam based course assessments and some of them do not react well to alternative continuous assessment methodologies.

Two questions were asked to the students about the assessment system and the way the subjects were taught. Hereafter are some of the students' comments:

Filipe Rôla (1999/00): 'This discipline is very relevant for future Mechanical Engineers. However, this relevance is somehow disregarded when analysing the overall picture of the Mechanical Engineering syllabus. My overall appreciation of the discipline and its assessment methods is good. However, and because the discipline was at its birth, some points could be improved: the individual performance in group assessment should weight more in the final lab component (group elements marks are excessively uniform); classes planning should be known since the beginning of the year; short tests on each theoretical class could improve the feedback about the knowledge of subjects; presentation of videos and other appealing material could also improve students' motivation in the theoretical classes.'

Filipe Mendes Lopes (1999/00): 'The continuous evaluation of students' lab performance and the written tests are clearly the most appropriated way for this type of discipline. Also, the hands-on experiments are very appealing, helping the application and integration of theoretical knowledge.'

Pedro Bandeira (2000/01): 'It is very pleasant to know that students' opinion is relevant when trying to improve this discipline. My overall opinion of the discipline is good since it is one of the few where students have hands-on experience. In fact, I think lab tasks are quite well organized. In terms of theoretical classes, however, the situation is different since nowadays students are constantly disturbed by side activities. Therefore, the inclusion of Information and Communication Technologies (ICT) components could improve students' attention during classes. Short experimental demonstrations would also be welcome.'

Pedro Portela (2000/01): 'I believe students should be given extra laboratory work, beyond the academic one. This way deeper knowledge of the subjects could be gained. These extra works could then be presented to their incoming colleagues, motivating and making them active participants. Case studies could be proposed in the beginning of the course. These case studies should be analysed by the students along the semester and a mark attributed to their approach towards a solution, even in the absence of a complete solution. As for the theoretical lectures themselves, I believe an intensive use of multimedia technologies should be put into practice replacing the old transparencies with modern animations, movies and pictures. This way the audience's awareness and attention would be easier to attract and keep. A lot of effort has already been put into this matter, but I recognize the difficulty to teach large classes.'

Jorge Almeida (2000/01): 'This discipline is very important to the mechanical engineering syllabus. In fact, what I learnt has been of vital importance not only up to the end of my degree but also in my current professional activity. Both group presentation and poster are an interesting way of assessment. The recently published interactive multimedia CD-Rom is a precious contribution for the discipline.'

Teresa Oliveira (2001/02): 'I am pleased to contribute to the development of 'Instrumentation for Measurements' pedagogical methods. The continuous assessment encourages constant study, thus contributing to the understanding of lab tasks. It would be better if lab groups could be reduced to two students. In terms of theoretical classes, experimental demonstrations should be included. Regarding the poster, it was an important experience, the first on Mechanical Engineering syllabus. Finally, this discipline should appear later on mechanical engineering degree.'

António Melro (2001/02): 'The 'receipt' style of practical working guides is quite limitative when searching a solution. It would be more interesting to present only the objectives to be reached and let the students to get there by their own. In this way team working skills and deep knowledge of subjects would be improved. Since this is a lab devoted discipline, a final individual hands-on examination should be part of the assessment methods.'

Pedro Farinha (2002/03): 'Students performance could be improved by a closer interaction between students and teachers in theoretical classes. There should be more guided problem solving classes. A positive element is the CD-Rom with interactive videos and animations.'

Manuel Luís Martins (2002/03): 'The continuous assessment encourages constant study and improves the comprehension of taught subjects.'

Tiago Oliveira (2002/2003): 'Generally speaking, the assessment criteria are adequate to the course. There is, however, one exception: the poster component, where subjectivity plays a major role. The diversity of the supporting material (Power Point presentations, CD-Rom and a short web-course) was a consequence of the teachers' effort to motivate students. Although the overall weekly lecture time should be maintained, it should be distributed along shorten sessions.'

José Vasconcelos (2002/03): 'Are you still concerned about pedagogy? In my opinion the discipline is very interesting, offering a very well structured continuous assessment. Its contents provide real tools for professional life. In this discipline, the supporting material is adjusted both to the developed activities and to future professional life. Its consistency and quality makes the distinction between a good or a bad discipline and a good or a bad teachers' team.'

SOME MORE THOUGHTS

When working with large classes, new strategies in pedagogy and in classroom management are very difficult to implement. Students have many different characteristics and are exposed to a multiplicity of side activities and constantly using new technologies. These facts and the experiments that were made led teachers to understand they have to gather new teaching ways for new student generations.

In the reported experiment, Lab sessions' articulation, assessment methodologies and learning matters seem to find a good agreement among students.

The main problem appears at theoretical lectures. We know that 'simple presentation of information guarantees neither that the ideas and concepts transmitted can be meaningfully integrated into students' existing knowledge, nor that they can be generalize to new problems', [10]. The team tried to introduce the use of ICT's in a complementary way, supporting syllabus matters with an e-book and through a short e-learning course. Also, students were assisted with all relevant information available in the course web page. At theoretical lectures, teaching subjects were shared between two members of the staff, using blackboard, Power Point slides and transparency materials, trying to conceptualise and to discuss typical theoretical problems. Nevertheless, students haven't been motivated neither to attend theoretical lectures nor to discuss ideas.

The authors know that there is still a long way to go. They also know that even if a satisfactory performance is achieved, new changes will soon be needed. In any case they believe that the main core of their activity should be focused in helping students' progress, pointing out new ways of exploring knowledge and stimulating students' creativity - in some sense, the creativity is always subjacent to the human capacity in solving new problems [11].

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