Evaluation Methodology in the Digital System Degree Course

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Abstract— **Evaluation methods must optimize the student learning process. In courses of the nature of Digital Systems, the practical application of the acquired knowledge is as important as the theoretical knowledge itself. On the other hand, the development of professional skills during the learning process is a key for the integral formation of the students.**

Keywords— evaluation methodology, Multisim, work group

I. Introduction

The evaluation of the acquired knowledge in technological subjects must cover different didactic aspects. On one hand, it is necessary to know if the student learnt the theoretical fundamentals of the subject, and on the other hand it is necessary to demonstrate that he/she is able to apply the acquired knowledge in practical cases. Moreover, fostering the self-learning process is key in any discipline nowadays, i.e., the student must know how to deepen in the subject and/or how to learn new concepts starting from the acquired knowledge. It has been demonstrated that students learn more when they are intensely involved in their educational process and are encouraged to apply their knowledge in several situations [1]. Moreover, the efficiency of the team work in the learning process is being increasingly researched and it is commonly agreed that the ability to work in teams is a critical competence in the formation of engineering students for the work place [2, 3].

Bearing these ideas in mind, the methodology of evaluation of the Digital Systems course has been developed. Firstly, the theoretical-practical knowledge is evaluated through a written exam, where some circuit designs must be analyzed, explained and in some cases designed. Secondly, the capacity of designing and simulating digital circuits is mainly evaluated by means of a test that consists in the simulation and analysis of three different cases using the Multisim tool. Finally, a group work on a subject related to Digital Systems allows the lecturers to evaluate the self-learning capacity and the ability to use the studied concepts and ideas, and also to check the students' aptitudes to explain new concepts to others.

II. Framework

Since the 2011-2012 year, the Digital System course has been taught fully in English in the third year of the following degrees in Tecnun, University of Navarra: Industrial Electronics Engineering, Telecommunications Systems Engineering and Electronic Communications Engineering. The course has 4.5 ECTS, which, according to the Bologna process, means an average of 112-135 hours of workload for the student. The teaching procedures have been adapted to the Bologna guidelines. This adaption to the Bologna guidelines means, on one hand, a higher implication of the student in his/her own learning process, and on the other hand a higher degree of practical application of the acquired knowledge. Furthermore, cross-curricular skills have also been worked out, for example the capability of working in a group and/or the ability to talk to other people and explain technical concepts to them. The final evaluation of the different aspects has been carried out in three ways:

1. A theoretical-practical written exam (55% of the final mark).
2. A test using the Multisim simulation tool (35%).
3. A work group on a subject related to Digital Systems (15%).

In the following paragraphs, the teaching procedures followed by the way the evaluation has been carried out will be clarified, focusing on the method to evaluate the group work and extracting some conclusions from such an evaluation procedure.

A. The theoretical-practical concepts and their evaluation

The course starts with a review on combinational circuits and logic simplification. After this short review, the contents are focused in an exhaustive learning of all kind of sequential devices, from basics on latches and flip-flops to counters and shift-registers. In all the cases the chapters are illustrated with real application examples and designs are proposed to the students, always using the data sheets of the circuits to understand how they work. A chapter on Finite State Machine design is also explained, also centering the attention on practical examples and implementation of real machines. In the final part of the course, a chapter on signal interfacing and processing and an introductory chapter to digital system implementation are given to the students.

The 70% of the sessions are carried out in the lecture hall, devoting half of the time to explain the theoretical concepts and half of the time to real application examples. The main aim of these sessions is to make students understand how digital circuits work, be able to read and understand data sheets and also to design them starting from known components.

The other 30% of the sessions take place in the computer lab. Practical examples are proposed to the students, where they have to design and simulate circuits using the Multisim tool. The students have free access to the Multisim through a student license so they can work out the proposed exercises and practical examples outside the computer lab.

Multisim helps students meet the present needs of experiment teaching. The simulated experiments are not only a whole advanced workbench but can also develop the ability of the students to analyze, apply and innovate in circuit design. If this is compared to the conventional way to perform experiments, this platform encourages the student-centered opening-up model on experiment teaching [5, 6].

This learning dynamics, alternating classroom sessions with lab computer sessions, allows combining the acquirement of theoretical knowledge with its practical implementation in real circuits, right after the concepts have been studied.

B. Work group and its evaluation

The procedure for the work group evaluation has been based on the work developed by the Industrial Management Department at Tecnun, Engineering School [4]. In this work, the factors that affect the effectiveness of team work in learning environments have been identified, in order to improve the teaching and learning of teamwork skills within degree programs. In their study, they include as a background experience from both academic and non-academic environments. The factors are categorized into three levels: institution-level factors (team-work related general rules, coordination, etc.), course-level factors (objectives and evaluation criteria, team structure, team evaluation, etc.) and team-level factors (team rules establishment, roles and task agreement). Their results showed that all the three groups are considered to be important by the students and also by the lecturers, so the procedure for the group work has been designed taking these results into account.

The students are given the subject of the group work at the beginning of the course. They have to present three different items:

1. A **"Group Agreement"** document. In this document, they have to write the rules agreed by the group members to carry out the project. It must include the following information:
    a. Structure of the team and agreed roles: for example who will be the secretary (who makes the calls for the meetings and takes the minutes), the administrator (who picks up all the generated information and keeps track of it), and the leader (who will be the representative of the group for the relations with the lecturers).
    b. Rules to carry out the work: about punctuality and/or attendance to meetings, how to carry out the group internal communication, how to make decisions (unanimously, by general consent), how to manage conflicts.
    c. Planning: number of meetings, where they will be held and how long they will take, etc.

    This document must be signed by the students and submitted to the lecturers two weeks after the beginning of the course. It is not marked, but it is a necessary condition to be evaluated, as well as a tool for the teacher in case of conflict between the students. The guide for contents indicates the minimum amount of information the lecturer is looking for, but any other relevant information can be included.
2. The second activity is a **presentation** on a subject related to the Digital Systems course. The presentation is made in front of two lecturers of the course, other lecturers from a different course, and the rest of the students. Although it is related to the subject, it has not been explained by the lecturers, so the students need to develop their comprehension and synthesis skills, first to understand the subject they have been assigned and then to be able to explain it to the rest of the students and to the lecturers. Some years they are asked to prepare a video of maximum 10 minutes with a previous short presentation of 5 minutes (without slides) and in other cases they were asked to present their work using the means they found more suitable: talk, power-point slides, etc.
3. The third item the students must hand in is a short **"Report"** of two pages containing at least the following information: structure/outline of the presentation, description content of the presentation (concepts explained, examples, other resources used). The students are given some clues to write technical reports and on the use of technical English and they are encouraged to use it in the report. Although English is not evaluated, the good structure and right language use is taken into account.

The group work is evaluated averaging the report and the presentation. The presentation is evaluated according to the following statements, which are marked from 1 to 10 (from "totally desagree" to "fully agree"):

- The presentation was clear/easy to follow.
- The presentation was adjusted to time.

- The whole group took part in the presentation.
- The idea was original.
- The technical concepts were clearly explained.
- The contents were adequate to the audience.
- I learnt something new from this work.

The evaluations of the lecturers are averaged among them and so are the students' (they carry out an agreed evaluation among the members work groups). On the whole mark, the weight of the lecturers' opinion is the 70% and the students' is the 30%.

The evaluation criteria for the course and all the explained details about the evaluation procedure were explained to the students at the beginning of the course, so they knew the way they were going to be scored in advance [7].

III. Work Group Results

The results of the work group are diverse. On one hand, the numerical values of the scores can be taken into account, and on the other hand, the qualitative observation of the lecturers on how the work groups have performed and how they evolved during the course can be analyzed.

As explained before, the group work presentation is evaluated both by students and lecturers. After listening to the presentations, and having the list of evaluation points in front of them while they are listening to their colleagues, they individually score the different aspects listed before. Afterwards, they have a consensus meeting to agree a final mark for each and send it to the lecturer.

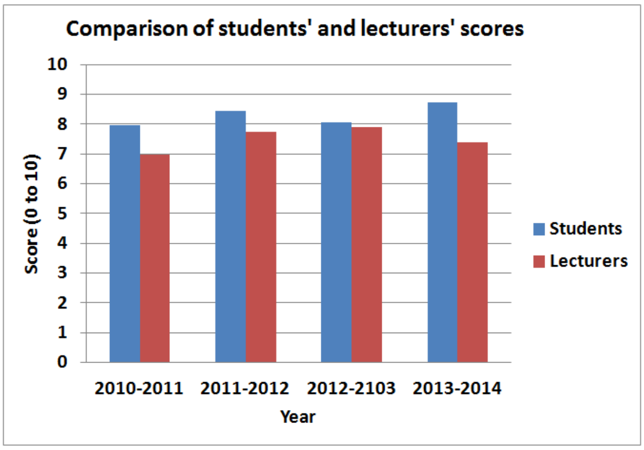

Figure 1. Comparison of students' and lecturers' average scores in group-works within four academic years

In Figure 1, the average work-group marks (from 0 to 10) given by students and by lecturers during four consecutive academic years are shown. It can be noted that the maximum difference is of 1.3 points in 2013-2014 while the minimum difference is 0.2 points in 2012-2013. In any case, it may be concluded that the level of agreement between lecturers and students is very high.

As well as this objective value, the lecturers have concluded the following in relation to the group work results:

- The group agreement is an effective tool to make students aware of the importance of work-planning.
- The group agreement helps lecturers being referee in case of conflict among group members.
- The report correction by the lecturers and subsequent feedback helps students improving their technical writing skills and their ability to summarize their work.
- The presentation of their work in front of other students allows them to advance in their presentation ability in general, and in their English delivery in particular.
- The fact of researching a subject which has not been explained in the lecture hall but is related to Digital Systems makes the students relate different aspects of their learning process, making links among different subjects and using cross-disciplinary skills, as they will need to do in their professional careers.

IV. Conclusions and Future Prospects

The evaluation procedure carried out in the Digital Systems subject tries to balance the different didactic aspects of learning, as stated in the introduction: theoretical fundamentals and practical application of knowledge, as well as cross-disciplinary skills.

As a first set of conclusions, the three evaluation parts and their respective weights in the final mark will be analyzed. It can be concluded that the Multisim simulation tool is more effective than the written exam in order to evaluate some aspects of the Digital Systems knowledge of the students such as:

- Circuit design and analysis ability.
- Failure analysis capacity.
- Simulation skills (signal dynamics, signal measurement).

In relation to this idea, increasing the relative importance of this part of the final mark as well as linking this tool to a real digital design is being considered

In relation to the group work, in order to be able to reach more quantitative conclusions it will be necessary to include specific questions on it in the student survey performed at the end of the year, for example on the satisfaction of students with the learning process or the difficulty of the group work, among others. The possibility of making group works a more global issue within the degree is being discussed among the different departments at Tecnun, so the students can perceive a global environment in which group work is encouraged at all levels and common strategies for their formation in this field are carried out. This way, interdisciplinary conclusions could be extracted from the different work group results.

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