Cooperative Learning in the Digital Electronics Course at the EPSC-UPC

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Abstract — *This work presents the experience of introducing the educational method of cooperative learning (CL) in the course of Digital Electronics. This course is compulsory and is one of the subjects that is included in the selective phase (the first two semesters) of the Bachelor's degree in Telecommunications Engineering of the Technical School of Castelldefels (EPSC), a school of the Technical University of Catalonia (UPC). This paper explains: the basics of the cooperative learning method, the context and syllabus of the subject in which the CL is applied, the systematic that has been applied for restructuring the subject which has been taught since now in the classic passive lecturing way, and the students' assessment.*

Index Terms — *Cooperative learning, collaborative learning, education, digital electronics, and teamwork*

INTRODUCTION

The cooperative learning (CL) method differs substantially from the classical passive lecturing way in which students merely take notes through the class time while looking at and listen to the professor. The later represents the old paradigm of teaching, as Johnson, Johnson and Smith [1] stated, while the former represents a new paradigm of teaching with many advantages that can produce a great improvement of the learning process.

Cooperative learning gets its strength in defining base groups by putting the students in small team environment to learn together the subjects for the whole semester. In the classical method of lecturing which is predominantly in use in the UPC, the student learn isolated, by his or her own, in a competitive way with his or her colleagues; so the cooperative approach represents a real change in the way the things will be organized at the school.

The author gets full support from the school staff and the GIAC [2] to try to redesign the way the subject of Digital Electronics is taught with the aim of improving the quality of learning. At the EPSC, several new experiments have been carried out by other professors with students of second and third courses of this bachelor degree, and even the second cycle career of Telecommunication Engineering (master degree) has been structured in Problem-Project Based Learning (PBL). Therefore, we have enough preparation and background to try this approach of cooperative learning directly to our new students, which come from high schools and possess no experience in university education.

It has to be said that the achievement of the whole potentiality of the new method cannot be done in a single semester. One has to proceed step by step, firstly reorganising the subject towards the new paradigm, and secondly trying to get the best of the five elements of cooperative teams (positive interdependence, individual accountability, face-to-face promotive interaction, interpersonal and small group skills, and group processing) in an evolutionary implementation in successive semesters as the instructors and the students gain experience.

SUBJECT CONTEXT AND SYLLABUS

Figure 1 shows the subjects of the selective phase of the studies of the bachelor degree in Telecommunications Engineering, indicating the position of Digital Electronics at the semester 1B of the first year. It has 6 credits: 4.5 credits of theory (3 hours per week) and 1.5 credits (1 hour per week) of application. No specific laboratory classes have been scheduled, but some practices including digital circuits have been programmed in the syllabus of the Electronics Laboratory subject at the same semester.

Figure 2 shows the relationship between Digital Electronics and the rest of the subjects of the area, which comprises compulsory and optional subjects in both specializations of the career: Telecommunications Systems and Telematics. It is intended that students finalising their bachelor career acquire enough knowledge in the area to implement digital systems of certain complexity. So, Digital Electronics introduces the area for the first time and, as indicated in Figure 3, the course has been divided basically in two parts of identical length: Combinational Systems (for the first seven weeks) and Sequential

Systems (for the last seven weeks). Additionally, some material for complementing the core program and introducing the subjects to be taught the following years have been included: lectures about ideas of microprocessors, hardware description languages such as VHDL, programmable logic devices PLD, and software for computer aided design of digital systems. In order to give a more practical orientation to the subject the design of an application project (AP), a practical exercise including real integrated circuits, is also scheduled during the semester.

SYSTEMATIC IMPLEMENTATION OF THE COOPERATIVE LEARNING METHOD

The systematic implementation of the cooperative learning method requires major changes in the academic activities and an initial preparation for the teachers far beyond the one needed for applying the classical method. It is compulsory to notify to the classroom that the students will have to work a mean of 8 hours a week in the subject. That is, they have to double the time indicated for the subject in Figure 1. For teachers, it is recommended starting to prepare the documentation of the subject several weeks before the beginning of the semester and searching advice from other staff that has been using the method before. The base groups will be of three students and they will keep working together for the whole semester.

The academic activities and the weekly sessions necessary for organizing the course from the cooperative learning point of view are listed in Figure 4. There is theory to be learned, exercises and problems to be solved, an application project to be designed, a portfolio to be prepared, and several examinations for assessing the level of the students knowledge to be scheduled. The regular sessions in classroom with presence of the teacher (4 hours per week) will consist in a lecture session (L) of 1.5 hours conducted by the professor, a teamwork session (TWA) of 1.5 hours and a teamwork session (TWB) of 1 hour developed by the students themselves. In addition, the students will have to conduct by themselves an extra teamwork session (TWC) of a length of 2 hours minimum at the study classroom or the library or even in their own home. Therefore, if the lecture is considered individual work, each student spends between minimum of 56 % and a maximum of 82 % of the time working cooperatively with his or her classmates of the base group.

Theory and student assessment are developed in both, sessions L and TWA, while problems, exercises, the making of the portfolio and the application project are resolved in cooperative sessions TWB and TWC. Teacher can monitor the group activity during regular sessions and can feedback corrected material to each team discussing the understanding and the progression of every student in the classroom. Figure 5 pictures how the cooperative environment is working in sessions TWA and TWB showing the very positive interaction produced between team members and with the teacher.

The portfolio is composed by the table of contents; exercises and controls proposed during the course; class notes and additional documents processed by the team; a register of the work done in every TWC session; and the memory of the application project and its oral presentation. Even an index of terms or glossary of the subject can also be included. The portfolio is a way for organising and classifying the academic activities during the semester, and without any doubt represents something new compared to the old way, where no one takes into account how the student structures its notes and how and when studies.

Before the beginning of the semester, it is essential that the instructors prepare carefully all the documentation and tasks for the students and for themselves:

- A detailed course syllabus including objectives, bibliographical references and description of student assessment. Additionally, a document for explaining how the subject is organized and the basics of the cooperative learning method is required.
- The weekly working schedule with indications of what will be taught in every session (there are about 45 sessions in the semester), which exercise will be proposed and which exercise will be picked up for correction.
- The digital campus (intranet) and even the web site of the subject where most of the digital *pfd* formatted documents will be kept.
- Reservation of special classrooms for developing teamwork sessions.
- Spreadsheets for entering individual and group marks and tracking the students progression. Even the weekly time each team devote to the subject can be recorded and graphically plotted.
- A document that lists the minimum knowledge that every student must acquire to pass the subject.
- A set of exercises ‘of minimums’ for practicing with the essential knowledge of the subject and design problems of more complexity to be developed during the semester.
- A list of titles of application projects to be selected by each team.
- A document for explaining the professor’s correction criteria of exercises and examinations.

In addition, documents for self-assessing the activity of the team and its portfolio can be prepared with the objective of allowing the students themselves to improve the quality of their work.

STUDENT'S ASSESSMENT SYSTEM

Student's assessment in the classical lecturing method consists simply in putting marks in a pair of exams and making its mean. On the contrary, assessment in the cooperative learning method is more complex because all the academic activities developed by the students contribute to the final grade. Most of the activities and tests are done cooperatively producing the same mark for the three members of the team. Equation (1) represents how the final grade is obtained at the end of the semester. The items stand for: EX exercises, a mean of 12 exercises proposed and corrected in a weekly basis; GC group controls, a mean of 2 or 3 tests realised each time by a different member of the team; MI minimums, a mean of 9 individual tests that comprise basic topics of the subject that everybody must learn if a pass wants to be achieved; AP application project, the mark of the practical design and its oral presentation; PO portfolio; and SUB subjective mark from the instructor.

$$Q = (EX + GC) \cdot 20\% + MI \cdot 30\% + (AP + PO + SUB) \cdot 10\% \quad (1)$$

Student marks are updated and posted in the digital campus every fifteen days allowing continuous evaluation of the progression of each team. Furthermore, as shown in Figure 6, each team is asked to record weekly the study time employed in the subject allowing even from the firsts weeks of the course the detection of problematic situations inside the teams that do not follow the expected dedication of 8 hours per week.

Figure 7 shows final grades for two different class groups involved in the experiment. Students of group 1B3 succeeded better than their colleagues of group 1B1, probably due to a much better interaction and trust between team members that in the end prevents individual failing. Such results prove that for the students themselves is not an easy thing getting involved in cooperative methods. Consequently, student training in social skills and small group dynamics is required for solving and preventing situations where for example there are students who refuse to work together.

CONCLUSIONS

The first results of the experience show that cooperative learning is a quite viable alternative to the classical way of lecturing at the university. However, it presents the serious drawback of requiring a considerable initial workload for the instructors to begin, as authors in [3] and [4] exposes. Once the experiment has been set up and the major changes and the documentation have been prepared during the firsts semesters, it still requires more time than the lecturing method essentially due to the large amount of material to be regularly corrected and delivered back to the students. Nevertheless, without any doubt, restructuring Digital Electronics has been a worthy experience that represents a commitment to excellence, something that must be continued and expanded to other subjects and even to the whole career.

Many actions can be pointed out to persevere and ameliorate this first experience for the next college years to come: self-evaluation of exercises and portfolios between teams; preparation of lessons and other class materials from cooperative learning point of view; introducing generic sessions to explain the basics of the new method to all the community; reducing lecture sessions and substituting them by teamwork sessions; and finally, trying to structure a colleagial teaching team.

ACKNOWLEDGEMENT

This work was sponsored in part by the project number 86MQD2002 of the Ministry of Universities, Research and the Information Society (DURSI) and the Agency for Administration of University and Research Grants (AGAUR) of the Generalitat, the Government of Catalonia. This work was sponsored in part by the Technical School of Castelldefels (EPSC) of the Technical University of Catalonia (UPC). The author will also acknowledge the support received from the Grup d'Interès en l'Aprenentatge Cooperatiu (GIAC) of the Institute of Education Sciences (ICE).

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FIGURES AND TABLES

FIGURE 1
SUBJECTS OF SELECTIVE PHASE CONSISTING IN SEMESTERS 1A AND 1B OF THE FIRST COURSE

	HT 3	HA 1	HT 4	HA 2	HT 3	HA 1	HT 2	HA 2	HT 2	HA 2	HT 1	HA 2
1A	**Fundamentals of Mathematics I**		**Fundamentals of Physics**		**Introduction to Computers**		**Electronic Devices and Circuits**		**Introduction to Engineering**		**Written and Oral Communication Techniques**	
	CT 4.5	CA 1.5	CT 6	CA 6	CT 4.5	CA 1.5	CT 3	CA 3	CT 3	CA 3	CT 1.5	CA 3

	HT 3	HA 1	HT 2	HA 1	HL 1	HT 2	HA 1	HL 1	HT 3	HA 1	HT 2	HA 3	HT 1	HA 3
1B	**Fundamentals of Mathematics II**		**Probability and Statistics**			**Linear Systems**			**Digital Electronics**		**Electronics Laboratory**		**Software Laboratory**	
	CT 4.5	CA 1.5	CT 3	CA 1.5	CL 1.5	CT 3	CA 1.5	CL 1.5	CT 4.5	CA 1.5	CT 3	CA 4.5	CT 1.5	CA 4.5

FIGURE 2
DIGITAL ELECTRONICS AND OTHER RELATED SUBJECTS IN CHARGE OF THE DEPARTMENT OF ELECTRONIC ENGINEERING

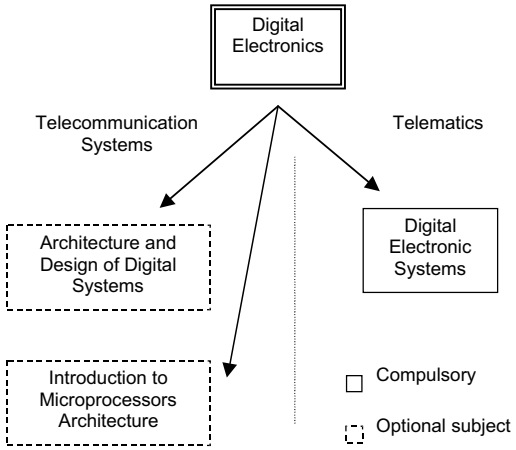


FIGURE 3
COURSE SYLLABUS

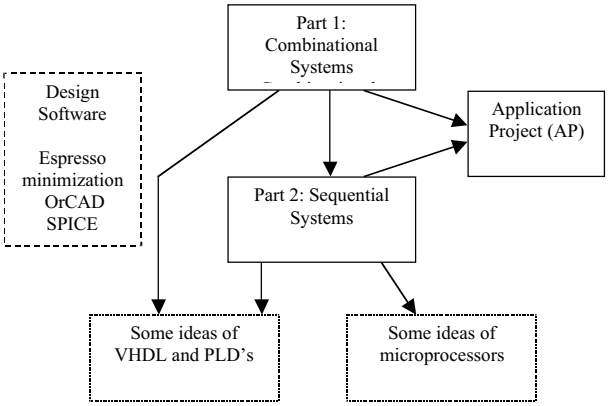


FIGURE 4
WEEKLY SCHEDULE FOR ACADEMIC ACTIVITIES AND THE SESSIONS WHERE THEY TAKE PLACE

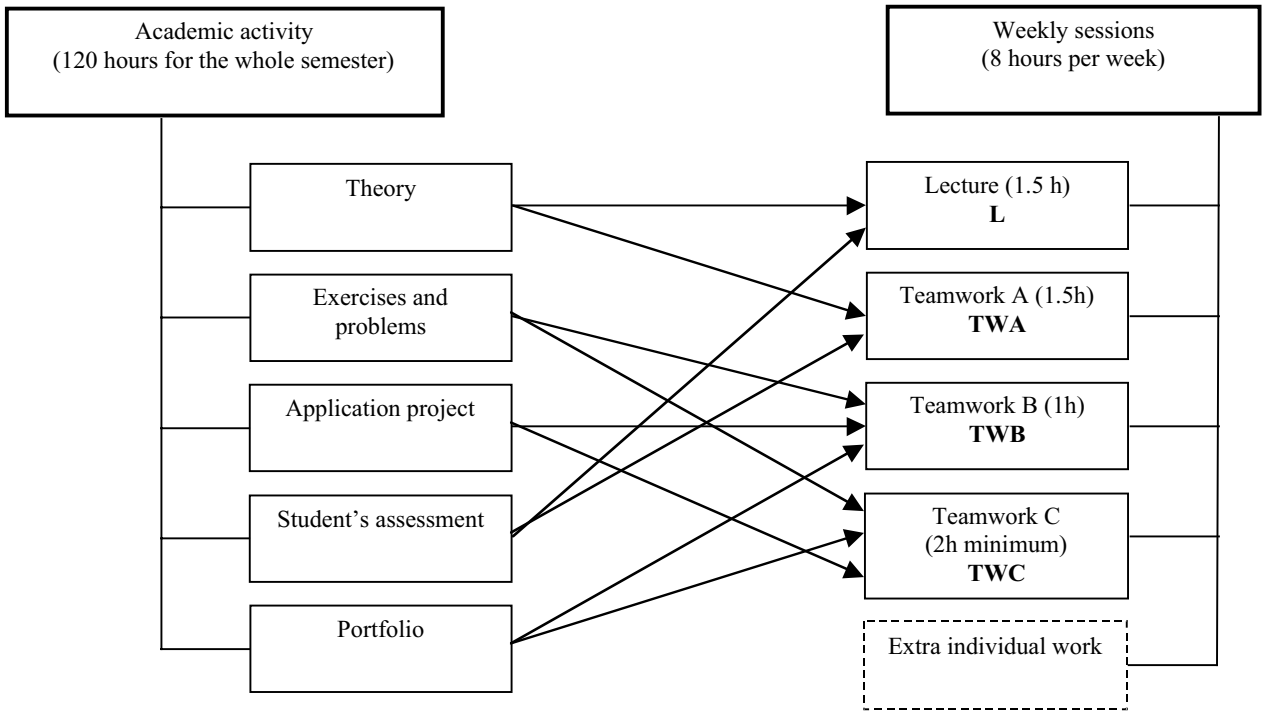


FIGURE 5
PICTURES OF THE COOPERATIVE LEARNING IN ACTION IN THE CLASSROOM

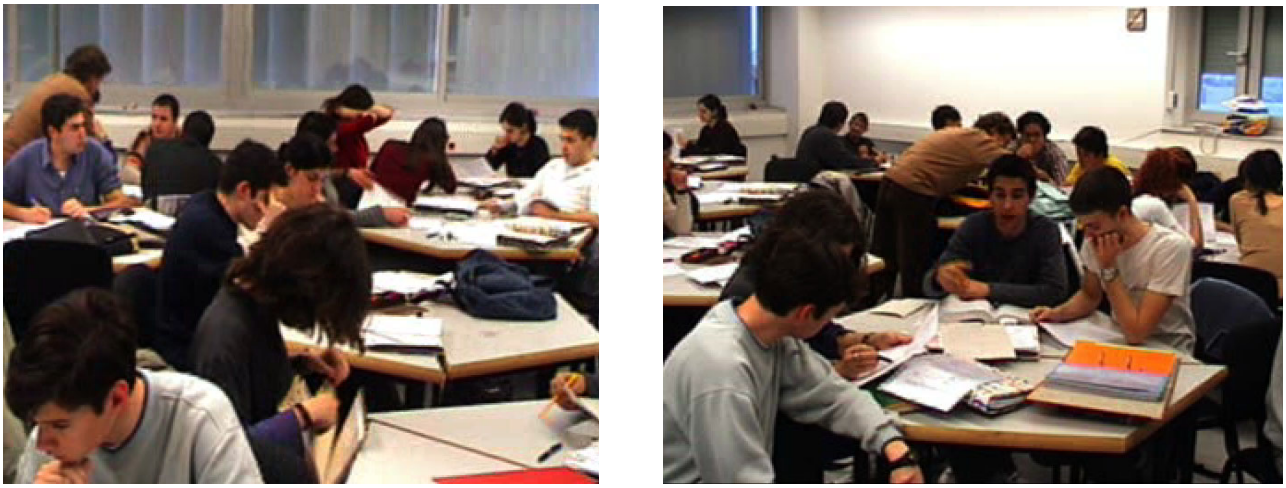


FIGURE 6
RECORDING STUDY TIME FOR EACH TEAM FOR THE COMPLETE SEMESTER WILL HELP MONITORING THE ACTIVITY OF EACH TEAM

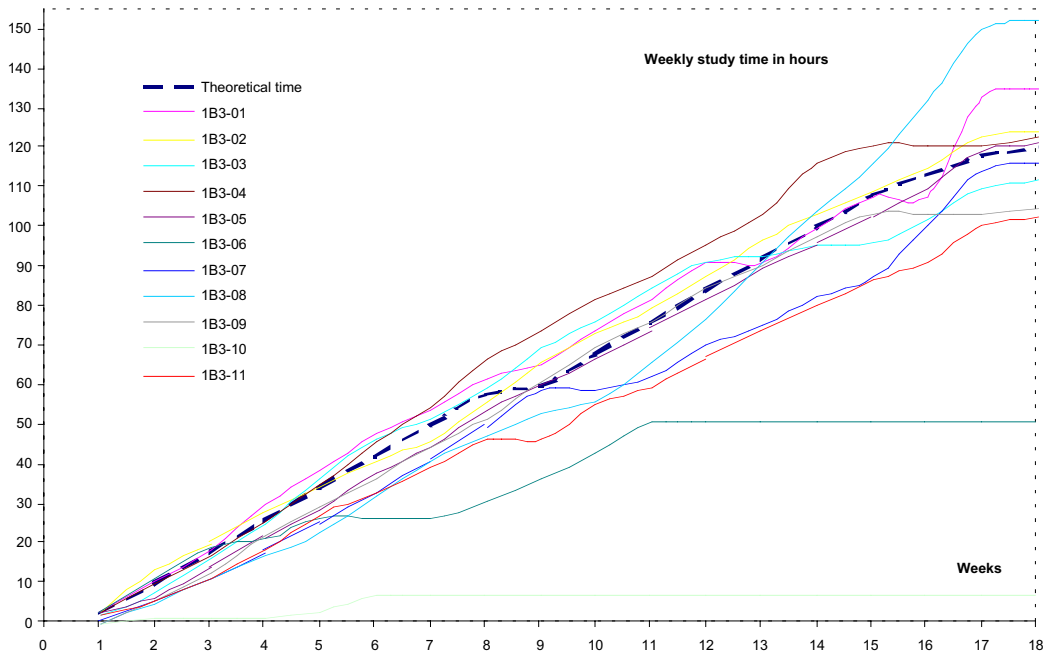
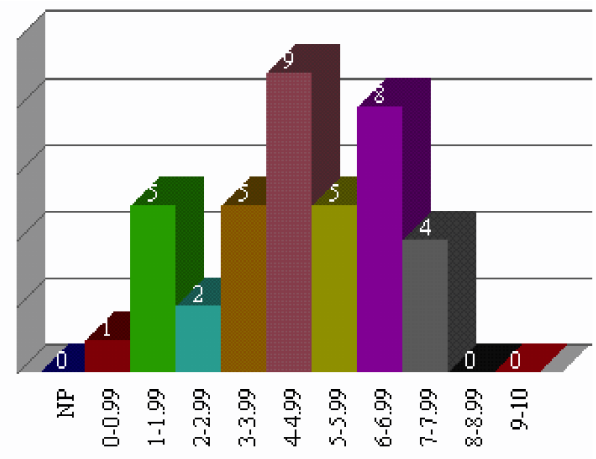
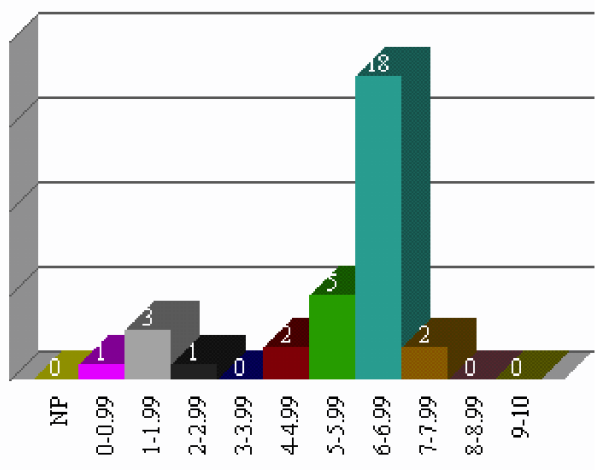


FIGURE 7
RESULTS OF THE STUDENT EVALUATIONS OF THE CLASSES 1B1 AND 1B3 AT THE END OF THE SEMESTER SHOW DISPARITY IN THE PERFORMANCE OF EACH CLASS



1B1 (pass rate 44%)



1B3 (pass rate 78%)