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Using Problem-Based Learning to help Portuguese students make the Bologna transition

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ABSTRACT

The Bologna Declaration has opened a stage of big and deep changes in the internal university organization, external cooperation, teaching models and methods, among other., all over the European countries. Here we will present and discuss a pilot experience conducted at the Engineering Department of the University of Trás-os-Montes e Alto Douro, Portugal, during the second year of that transition period. In brief, we will present a set of non-mandatory courses proposed to the students of each individual syllabus, with one hundred hours duration, each, approximately seven hours/week, fifteen weeks long, with the permanent help of a specialized trainer to aid the students in their "homework". The formal bureaucratic transition is also presented. Design and implementation issues, supported on problem-based learning and experimental lab learning classes, final assessment results, as well as the opinion of the students, are presented and analyzed. We believe that this methodology helped to make the transition smoother to the students, but also to the teaching staff.

Keywords: Bologna process, higher education, problem-based learning, experimental laboratorial learning classes

INTRODUCTION

The Bologna Declaration, signed back in 1999, has opened a stage of big and deep changes in the internal university organization, external cooperation, teaching models and methods,

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among other, all over the European countries. When additional variables are considered, such as financial constraints, the birth and dissemination of new tools and methodologies for the teaching/learning processes (e.g., distance learning), etc., these changes are in order to be happening in a very near future, if not happened yet.

In our view, and in accordance with Haug (2008), these changes reflect a desire to promote mobility and Europe as a world force in higher education in face of challenges from elsewhere in the world, and to establish the European Higher Education Area. This can only be achieved starting with a Europe-wide restructuring and harmonization of higher education and studies (Jacobs and van der Ploeg, 2006; Marks and Tesar, 2005). In the engineering education case, many studies are showing that a colossal work is being done throughout many different European countries (Munoz-Guijosa et al., 2009; Neal-Sturgess, 2007; Torres-Leza et al., 2004, to name only a few). Indeed, the achievement of Bologna's goals will only succeed if different national contexts are carefully considered.

Of course that the changes introduced with the Bologna process present important and big new challenges to the teaching/learning process in all Portuguese (and European) universities. Here we will present and discuss an initiative that was implemented at the Engineering Department of the University of Trás-os-Montes e Alto Douro (UTAD), Portugal, during the second year of the transition period. In brief, it consisted of a set of non-mandatory (volunteer) courses for each curriculum (with one hundred hours duration, each, approximately seven hours/week, fifteen weeks long, with the permanent help of a specialized trainer to aid the students in their "homework"), in order to try to make the transition smoother to the students, but also to the teaching staff (at least because of the necessary change of habits). Additionally, we believe that the results and discussion presented here will help in understanding that it is possible to share the human and material resources involved during the mastering of these curricula. The design of these courses was based on problem-based learning principles and experimental lab learning classes. Although this pilot experience has been successfully applied to the Electrical & Computers Engineering (ECE), Informatics (INF), Communication and Multimedia, Information & Communication Technologies (ICT), and Human Rehabilitation Engineering curricula, the discussion and results presented here will be focused on the ECE, INF, and ICT curricula.

The paper is organized as follows. In section 2 we present the formal/bureaucratic transition to Bologna in Portugal, and at UTAD and its Engineering Department in particular. Section 3 is used to present the experiential learning model that we have adopted to design the courses. In section 4 we present and discuss the non-mandatory courses that were proposed and in section 5 some of the results achieved. The paper ends with the presentation of some final remarks and conclusions, in section 6.

THE BUREAUCRATIC TRANSITION

According to Noam (1995) universities have three main functions: the creation of knowledge (research); the storage of knowledge (libraries); and the transmission of knowledge (teaching). It seems that the Portuguese higher education system is also organized according to these vectors, but it is being deeply restructured, particularly in what relates to the teaching and research dimensions. Some of these modifications are being imposed by changes in the Portuguese Law (e.g., DL7, 2006; RJI, 2007), and some others are being advised by the research funding policies dictated by the Portuguese Science and Technology Foundation (http://www.fct.mctes.pt/).

The Portuguese higher education system includes universities and polytechnic colleges. Now, and starting from the 2006/07 academic year with the effective publication of the Portuguese Decree-Law DL7 (2006) which marked the transition to the Bologna paradigm, we have three cycles of higher education: the first cycle "mobility degree" (Bachelors) is three years long; the second cycle "Master's degree" (MSc) after two more years of study; and the third cycle "Doctor of Philosophy degree" (PhD) with three more years. The majority of the curricula taken in polytechnic colleges only lead to "mobility degree" award. Also, no PhD degree can be provided by polytechnic colleges. In our opinion, there are two main reasons that greatly contribute to this: the lack of PhD teachers in the teaching body, and the lack of research centers to which the teachers are attached as researchers. These facts raise an important question that needs to be answered by the polytechnic schools: what to offer to the students that wish to pursue a PhD degree (and in some cases, even an MSc degree)? A solution to this problem may include the celebration of cooperation protocols between institutions.

The transition has also imposed an important reduction in the total number of contact hours per week (number of mandatory lessons per week), typically a reduction from about thirty hours to a little bit more than twenty; this reduction was achieved mainly by reducing the number of compulsory practical/laboratorial classes component. We believe that this reduction contributes to the moving of the center of the teaching/learning process from a "classroom/teacher" to "homework/student". Also, some flexibility in the curricula was introduced, in contrast to the traditional Portuguese way of teaching where the full curricula were already defined, tending to be very static with a very small number of optional courses for the student to choose, occurring mainly at the last (fifth) year of the old curriculum.

In all Portuguese universities, the different curricula were not adapted (or restructured) to the Bologna paradigm all at once; instead it had taken several steps or different phases (Cardoso et al., 2007). The universities have restructured their curricula in groups or sets. All the curricula were adapted by the end of 2009. At UTAD, a small university with about 8000 students located in northeast Portugal, this adaptation was done in three main phases: the first

included 15 curricula, 2006/07 academic year; the second 54 curricula, 2007/08 academic year; and the third, 31 curricula, during 2008/09 academic year. As we can see, 100 curricula were adapted to the Bologna paradigm, including first, second and third Bologna cycles.
The Engineering Department (ED) of UTAD has approximately 1700 students (including all cycles of teaching). Table 1 shows the main phases of the curricula's restructuring that the ED was responsible for. Although not shown in the table, we have restructured the two PhD curricula (Electrical & Computers Engineering, and Informatics) that the Department offered at that time.

Table 1 - The three phases of curricular restructuring at the Engineering Department.

Cycle	2006/07	2007/08	2008/09
1st	3	5	1
2nd	2	5	—

PEDAGOGICAL MODEL

Our pedagogical model is based on the Experiential Learning Model (ELM) of Kolb and Fry (1975), in conjunction with Problem-based Learning (PBL) (Hmelo-Silver, 2004; Barrows, 1986), and experimental lab learning classes. The ELM is composed of four elements: concrete experience; observation of and reflection on that experience; formation of abstract concepts based upon the reflection; testing the new concepts. These four elements are the essence of a "spiral of learning" that can begin with any one of the four elements, but typically begins with a concrete experience. This model emphasizes its links to ideas from John Dewey (1938), Jean Piaget (1941/1952), and others, writers of the experiential learning paradigm, and the importance of cooperation and interaction between students during their construction of learning (Vygotsky, 1978). This model was developed mainly for use with adult education, but has found widespread pedagogical implications in higher education.

PBL, which is a special case of "Inquiry-based learning" (Bruner, 1961), is being widely and successfully used to impart education in engineering (see, for example, Maskell and Grabau, 1998; Johnson, 1999; Mandal et al., 2000; Ditcher, 2001; Cheng et al., 2003; Prince, 2004; Dunlap, 2005; Smith et al., 2005; Prince and Felder, 2006; Hsieh and Knight, 2008). Although applications of PBL vary, it has three essential characteristics: problems as a stimulus for learning; tutors as facilitators; and group work as stimulus for interaction. Some researchers argue that this model has the potential to prepare students more effectively for future learning, because it has its roots on the above mentioned ELM, and it is with characteristics of being: constructive, self-directed, cooperative, and contextual. However, the detractors concluded that PBL students showed potentially significant gaps in their cognitive knowledge base and did not demonstrate expert reasoning patterns, and that PBL was very costly (Albanese and Mitchell, 1993).

PBL goes beyond the typical teaching methodology by promoting student interaction. Students are assigned to teams and provided with an “ill-defined” problem. Teams must organize themselves, define objectives, assign responsibilities, conduct research, analyze results, and present conclusions. PBL (Woods, 1994), can be seen as the process of using a problem situation to focus the learning activities on a need-to-know basis. This contrasts with subject-based learning, where the students are presented with discipline-based material and are then given a problem (or example) of its use. As put by Maskell and Grabau (1998), “PBL is ideal for engineering education as it encourages a multidisciplinary approach to problem solving (which is essential for modern engineering practice) and develops techniques and confidence in solving problems which have not been encountered before”. PBL naturally integrates various fields of study as students search beyond the traditional curricular boundaries to develop solutions. Also, combining PBL with cooperative learning (Johnson et al., 1991; Smith, 1995) provides a mechanism for students to maximize their own and other group members’ learning by working in teams to accomplish a common task or goal. Consequently, the proposed methodology is not limited to paper study, allowing the use of multimedia methods, including the use of different engineering tools, such as the ones reported in Reis and Ferreira (2004), Nobre et al. (2009), and Baptista et al. (2011).

THE COURSES

Because specialization within science and engineering degree programs results in students entering engineering curricula at UTAD with considerable differences in knowledge skills, it was decided to implement the courses as cooperative PBL ones, so that students could work together to maximize their own and each other’s learning, and consequently during experimental laboratorial learning classes. In addition, the groups were selected at random from the different degree programs and, in general, consisting of two members.

After lecture notes have been read, it is necessary to try a simple exercise to evaluate whether the students have grasped a concept; as stated by Cheng et al. (2003), “In order to attract user interaction, the exercises must be simple, straightforward, and taught through the lecture notes”. So, during the courses sets of small problems were designed and authenticated by senior teachers, and given to students. These problems are not truly open-ended but broad enough to serve the purpose. Probably, the greatest challenge in PBL is to create sufficiently broad and, at the same time, well defined problems so that the entire course curriculum is covered. Creating several smaller artificial problems concerning a few well-defined details is often easier than creating a larger one covering several predetermined topics. However, we must remember that some students may feel that PBL is too demanding, especially if PBL is applied directly without modification, because it requires students to learn a subject through their own study. This is especially difficult for the Portuguese students who have been using theoretical classroom teaching for a long time, which could be called “first time” PBL students, and so the application of a model like the “Aalborg model” (which gives the students the possibility for independent learning to achieve knowledge and skills at a high academic level) would be impossible (even for the teaching staff). So, the proposed set of problems during each individual non-mandatory course can be seen as modified-PBL: the necessary information is given to the students, but still retain some degree of self-searching.

The non-mandatory courses have one hundred hours duration, each, approximately seven hours/week, fifteen weeks long, with the permanent help of a specialized trainer to aid the students in their own work, and was linked to one or more mandatory course of the graduation curriculum. The chosen mandatory courses were the ones where students traditionally were having more difficulties, but several other academic issues were also considered, such as coordination between courses taught, adequate subject knowledge on the part of teachers, coordination between departments and lecturers in charge of courses, overlap between courses, and so on, before the courses were designed. Particular emphasis was given to the coordination between the different courses' contents, in order to promote complementarity and give students more time and space to practice and solve their problems, and reflect on how the different parts fit together, contributing to the desired solution. Other problems solved were the ones arising from factors such as the excessive number of tests or exams that students have to take by the end of the semester, forcing them to skip classes to study for those exams, or the coordination problems caused by the holidays.

The teachers of the mandatory courses (senior-teachers) were responsible to master the different subjects, encouraging the students to do their practical "homework" in the non-mandatory courses, with the help of the specialized trainer. The classrooms where the students attend these non-mandatory courses were specially equipped with multimedia equipment, like desktop computers and multimedia projectors; the teachers and the specialized trainers always have access to this equipment and also laptop computers. This kind of organization promotes the permanent interaction between the students and the teachers/trainers, the pedagogical group being augmented in the role of learner facilitator.

The student attendance in a classroom context will help him/her to better understand the foundation information, which will enable the student in its reflection, progression and action plan development. In order to better implement the students' plan, the specialized trainer (and the senior-teacher) helps the students in their groups (of two, and in some cases three), but also individually. These groups will also help the students to understand and learn how to do "team-work" (of course that the trainer must see him/her-self as an adviser). This approach allows working in a classroom context, fostering the "learn-by-doing", allowing for individualized pedagogic support, and promoting learning by putting theory into practice. Like Aristotle once said "For the things we have to learn before we can do them, we learn by doing them" (Bynum and Porter, 2005, 21:9).

Table 2 - Non-mandatory courses and mandatory courses actually contributing to their mastered contents (1st semester).

Non-mandatory courses	Mandatory courses	Curriculum & Year	Proposed	Mastered	Students
ICT Introduction	Computational Logic Seminar I	INF & ICT 1	5	6	86
Advanced Computer Programming	Programming Methodologies II Informatics Laboratory II	INF & ICT 2	5	4	66
Information Systems	Information Systems I Informatics Laboratory II	INF 2	1	2	31
Web Technologies	Programming Methodologies IV Informatics Laboratory IV Data Bases	INF & ICT 2	4	2	36
Information Systems Administration	Computer Systems Administration	INF & ICT 1 (MSc)	1	2	30
Computational Laboratory I	Control Systems Data Communication	ECE 3	3	3	51
Operating Systems Laboratory11	Operating Systems	ECE 3	3	1	11

Table 2 shows the first semester 7 non-mandatory courses and their corresponding 13 mandatory courses in the corresponding curricula. Also shown are the curricula and academic year of the students applying to the course. Note that the "Information Systems Administration" non-mandatory course was applied to "Master level" students, both from INF and ICT curricula. The listed mandatory courses are the ones directly contributing to the contents mastered during the non-mandatory courses, that is, not the ones that could contribute with contents, but rather the ones where it was possible to put the senior teachers responsible for their mastering together, and agreeing with the contents and "homework" to be done by the students. The "Information Systems" non-mandatory course was offered, as all the others, to the students of both INF and ICT curricula, but only students from INF applied to the course; students from ICT curriculum applied to this course only in the second semester. Also note that the number of proposed non-mandatory courses is not coincident with the number of actually mastered, because the number of students wanting to attend the courses was different from the one that we have expected; the grand total was 22 proposed and 20 mastered courses. Also we had 311 students attending the non-mandatory courses during the first semester.

Table 3 shows the second semester 7 non-mandatory courses and their corresponding 11 mandatory courses in the corresponding curricula. As we can see, the "Digital Image Concepts" non-mandatory course was applied to "Master level" students, both from INF and ICT curricula. Note that the "Information Systems" non-mandatory course was now offered to the students of the ICT curricula. The total number of proposed non-mandatory is now 19, but we have actually mastered 23 courses, due to the number of students wanting to attend these courses; in total we had 333 students attending the non-mandatory courses during the second semester. As we can see, there was an increment of almost 10% in the number of students attending the non-mandatory.

For the sake of brevity, here we present only the main objectives of the “Computational Laboratory I” non-mandatory course. Its main aims are: overview of the Microchip 8-bit PIC family; peripherals and records; configuration registers; peripherals, I/O ports, asynchronous serial port, ADC, counters and timers; interrupts, I/O port and timers.

As noted above, during the classes different sets of small problems were proposed, and a final bigger (“ill-posed”) problem at the end of the course. As an example, table 4 presents the set of tasks/problems proposed to the students of the “Computational Laboratory I” non-mandatory course. As we can see from table 4, most of these problems can be regarded as tasks, i.e., small steps to be taken towards the route that leads to the final solution. Table 5 presents the final proposed problem to the students attending this non-mandatory course. As we can see, a big part of the required work was done during the smaller tasks/problems listed in table 4. This is an “ill-posed” problem; surely, there will be groups students with “more complete” (and complex) solutions, but all the groups of students may reach a suitable solution.

Table 3 - Non-mandatory courses and mandatory courses actually contributing to their mastered contents (2nd semester).

Non-mandatory courses	**Mandatory courses**	**Curriculum & Year**	**Proposed**	**Mastered**	**Students**
Information Systems	Information Systems II	INF 2	2	2	31
Digital Image Concepts	Digital Image Processing	INF 1 (MSc)	1	1	21
Computer Programming I	Programming Methodologies I Informatics Laboratory I ICT Laboratory I	INF & ICT 1 (MSc)	5	6	69
Computer Programming II	Programming Methodologies III Informatics Laboratory III ICT Laboratory III	INF & ICT 1 (MSc)	3	4	72
Computer Networks	Computer Networks	INF & ICT 3	4	6	84
VLSI CAD	Electronics and Computation Laboratory	ECE 2	2	1	11
Computational Laboratory II	Telecommunications	ECE 3	2	3	45

Table 4 - List of problems/tasks presented to the students during the “Computational Laboratory I” non-mandatory course.

I/O
1. Write a small program that puts the DS1 LED flashing.
2. Write a small program that lights up the LEDs from left to right.
3. Write a small program that lights up the LEDs from left to right, and then form right to left.
4. Write a small program that: while SW1 switch is pressed the DS1 LED lights up, and when SW1 switch is released DS1 LED will turn off.
5. Write a small program that lights up the LEDs from left to right, and when SW1 switch is pressed the LEDs will light up from right to left.
6. The same as 1.5, but using Port A interrupts.
ADC
1. Write a small program to configure the ADC to the following values:
a) Channel: AN0;
b) Reference voltage: Internal;
c) Sampling frequency: Fosc/8.
The program should read the ADC output value and store this value in Volts.
2. Write a small program to read a sensor temperature value connected to RA1 pin.
3. Implement a digital voltmeter using the input pin RA0 and LEDs DS0 to DS7.
Timer
1. Write a program that will put the DS0 LED flashing exactly every second.
2. Implement a digital voltmeter to make acquisitions of 200ms.
3. Implement a frequency meter, to measure the frequency of a signal applied to pin T0CKI.
4. Implement a state machine to control the DS0 LED. The following states should be implemented: readSwitch, turnonTunroffLED.
USART
1. Write a program to send character 'A' from the development board to a PC.
2. Write a program that allows a PC to control the SD0 LED. Implement the options: turn on the LED, and turn off the LED.
3. Write a program to connect two development boards using USART serial communication capabilities. One of the boards should control the DS0 LED of the other board, turning it off and on by pressing the SW1 switch.

Table 5 - Final problem proposed to the students attending the “Computational Laboratory I” non-mandatory course.

Develop a program to control and monitoring the temperature and brightness of a room. The following sensors should be used: LM50 for temperature, and TSL 2550 for the following characteristics: port to turn on/off the heating. The program should include the temperature it will be used a fan for cooling and an output brightness. To control
1. The control should be implement using a state machine with the following states (with a range of 100 milliseconds):
a) readTemperature;
b) readBrightness;
c) controlHeatCool;
d) sendDataPC;
e) searchPCRequests.
2. The temperature should not fall below 15^{o} C nor rise above 27^{o} C degrees. Once activated, each driver must be turned on, at least, 1 minute, regardless of the hysteresis in the operation.
3. The information collected by sensors and state of the actuators should be sent to the PC each cycle of the state machine (Baud 9600).
4. The PC may start and stop the operation of the entire system; so, it will be necessary to implement the code to accept PC's requests.

Table 6 - Global final (end-of-semester) assessment results of the mandatory courses, for the first semester.

Mandatory courses	Enrolled	Attending non-mandatory courses						Non-attending non-mandatory courses					
		Total	Succeeded		Non-succ.		lacked	Total	Succeeded		Non-succ.		lacked
			total	class	total	class			total	class	Total	class	
Computational Logic	128	81	52	13.1	19	6.9	10	47	13	14.5	6	7.5	28
Programming Methodologies II	121	65	30	12.0	34	2.0	1	56	11	11.0	43	1.0	2
Programming Methodologies IV	50	27	22	12.4	3	7.0	2	23	15	11.9	3	6.7	5
Computer Systems Administration	49	30	19	12.7	11	5.3	0	19	4	15.0	1	2.0	14
Seminar I	124	77	77	15.4	0		0	47	19	14.7	0		28
Informatics	125	81	49	12.4	14	4.1	18	44	4	12.5	2	2.0	38
Informatics Laboratory II	93	53	34	12.4	10	5.7	9	40	8	10.3	2	4.6	30
Informatics Laboratory IV	47	27	26	12.8	0		1	20	17	12.9	0		3
Information Systems I	53	31	16	12.4	9	6.8	6	22	1	13.0	2	6.5	19
Data Bases	45	24	24	12.5	0		0	21	13	12.4	2	7.0	6
Control Systems	52	51	51	14.4	0		0	1	1	12.3	0		0
Data Communication	19	15	15	13.4				4					4
Operating Systems	32	11	11	15.6	0		0	21	7	12.2	2	5.7	12
Total	938	573 61%	426 74%	13.2	100 17%	5.4	47 8%	365 39%	113 31%	12.7	63 17%	4.8	189 52%

RESULTS

Table 6 shows the first semester global final (end-of-semester) assessment results of the mandatory courses that contributed to the contents mastered in the non-mandatory courses. Note that both students attending and non-attending the non-mandatory courses have taken the same final (end-of-semester) exams. From the grand total of 938 students enrolled in the mandatory courses, there were 573 (61%) students attending the non-mandatory courses and 365 (39%) not attending any of these courses; the same student may be enrolled in more than one course, i.e., we do not have 573 different students, and this too applies to the ones not enrolled. To analyze the data presented in this table we begin to notice that the total number of students attending the non-mandatory courses is 22% higher than the ones not attending. The average grade (labeled "class." in the table), for the students attending the non-mandatory courses, is better for seven mandatory courses (Programming Methodologies II, Programming Methodologies IV, Seminar I, Informatics Laboratory II, Data Bases, Control Systems, and Operating Systems); for the ones succeeded, the total average was 13.2 (in 20) for the attending students and 12.7 (in 20) for the non-attending students; for the ones not-succeeded the average was 5.4 (in 20) for the attending students and 4.8 for the non-attending students. Also, we note that the number of students labeled “lack” (students that had given-up, missed or that do not have the minimums required to do the final exam, and consequently fail) was bigger in students not attending the non-mandatory courses (47/8% students attending the non-mandatory courses, and 189/52% students not attending the non-mandatory courses). In total there were 426/74% succeeded students attending the non-mandatory courses, and 113/31% succeeded students not-attending the non-mandatory courses. Also there were 100/17% non-succeeded students attending the non-mandatory courses, and 63/17% non-succeeded students not-attending the non-mandatory courses, in total.

Table 7 - Global final (end-of-semester) assessment results of the mandatory courses, for the second semester.

Mandatory courses	Enrolled	Attending non-mandatory courses						Non-attending non-mandatory courses					
		Total	Succeeded		Non-succ.		lacked	Total	Succeeded		Non-succ.		lacked
			total	class	total	class			total	class	total	class	
Information Systems II	31	31	29	15.2	2	8.7	0	0	0		0		0
Digital Image Processing	21	21	21	14.3	0		0	0	0		0		0
Programming Methodologies I	147	69	65	13.8	2	6.7	2	78	40	13.3	30	5.6	8
Informatics Laboratory I	82	67	60	13.9	7	6.4	0	15	7	12.2	4	7.2	4
ICT Laboratory I	63	60	58	12.4	1	7.3	1	3	2	13.2	0		1
Programming Methodologies III	104	72	69	11.9	2	6.5	1	32	15	12.1	2	7.1	15
Informatics Laboratory III	29	29	28	13.2	1	7.8	0	0	0		0		0
ICT Laboratory III	39	38	38	12.8	0		0	1	0		1	6.8	0
Computer Networks	84	84	75	12	5	5.6	4	0	0		0		0
Electronics and Computation Lab	33	11	11	14.2	0		0	22	9	12.8	9	4.5	4
Telecommunications	80	45	43	13.2	2	6.5	0	35	15	12.7	10	5.8	10
Total	713	527 74%	497 94%	13.4	22 4%	6.9	8 2%	186 26%	88 47%	12.7	56 30%	6.2	42 23%

As we can see from the values presented in table 7, there were 527 (74%) students enrolled at least in one non-mandatory course, which corresponds to an increment of 13% from the first to the second semester. From these students, 94% were succeeded in the final exam, contrasting with the 47% of the succeeded students not attending any of the non-mandatory courses. Note also an increment of 20% in the number of succeeded students attending the non-mandatory courses, and a reduction of 13% in the number of succeeded students not-attending any of the mandatory courses. The percentage of non-succeeded students was 4% for the ones attending non-mandatory courses, and 30% for the ones not attending. For the students that had lacked the final exam we have 4% and 23% for the ones attending and not attending, respectively. In what concerns to the final total average grades, we can see that they are all better for the students attending the non-mandatory courses than for the students not attending them, except for the “ICT Laboratory I” and “Programming Methodologies III” courses, where the final averages are better for the students not attending the non-mandatory courses; although this is true, one must note the small number of students (3) not attending the non-mandatory courses for the “ICT Laboratory I” course.

Comparing the total number of students enrolled with at least one mandatory course during the first and the second semester, we can see a reduction of 24% (from 938 to 713), but this reduction was not fully reflected in the number of students attending the non-mandatory courses, which was of 8% only. This fact is even reinforced when we compare the number of mandatory courses contributing to the non-mandatory courses, which was of 13 in the first semester and of 11 in the second semester.

During the academic year we have also conducted a set of fifty semi-structured interviews to the students, in order to have some feedback and possible correct some of the choices that we have made. The data were collected and analyzed according to the methodology proposed by Bardin (1977). In global terms, we have reached the following major conclusions: first, the students were not used with the new methods of learning/working; second, they are enrolled with too many courses at one time; third, due to the number of different courses, plus the non-mandatory ones, they are having time-table (scheduling) problems; fourth, in the case of MSc level, some of the students are already employed; fifth, the difficulty level imposed on the MSc thesis by some advisors (which were used with the old MSc figurine), is to high (recall that the former MSc degree was preceded by a five years curriculum, plus one more year of lectures, which ended up with the dissertation’s writing, and that by now it is after a three years curriculum, followed by one more year of lectures, and a final year to write the dissertation, but also with mandatory lectures, i.e., a reduction of two years). Some of the individual testimonies reinforce these facts: when asked if they are used to this methodology the answer was invariably “no”, and that they “rather prefer this kind of approach, instead of more theoretical ones” (interview # 5) or “it really helped me understanding some basic facts and guiding and programming/scheduling my study” (interview #45) and “this (initiative) helped me with more (mandatory) courses than I was expected, even though I almost have no extra time for anymore courses” (interview #25). Also, the students feel that “besides it particularly helped me in my different courses, it also entailed a kind of approximation between the students and the teachers” (interview #12), and that “even though I’m still convinced that my MSc advisor is pushing the level to high, I feel that now I’m more close to him than before” (interview # 2). In line with these opinions, “the (non-mandatory) courses helped me to see «the big picture», and how things relate to each other” (interview #40), “this gave me extra motivation to purse my objectives, because every time I have any question I can go to the teacher or the trainer and ask them what to do; I feel they are always close to me” (interview #20), or “I was really thinking quitting one or two (mandatory) courses (because of the great number of mandatory courses I was enrolled with), but the words, patience and support of the trainer stimulated me to continue and not given up" (interview #23). It is worth to note that students feel that the curricula are better after the Bologna restructuring (e.g., "I think that the subjects mastered along the several courses are more linked between them than before" (interview #5) or "now, things make more sense" (interview #15), "now I can see I how the different subjects mastered along the different courses fit together" (interview #39). Also, in their opinion, this kind of initiative should be encouraged and maintained, mainly because of the help they had during their "homework" and the feeling of "proximity to the teaching staff".

CONCLUSIONS

The transition to the Bologna paradigm was very sharp, and both students and teachers still have much and hard work to do. Here we have presented a methodology intended to particularly help the students in this transition. It was successfully applied to students from Electrical & Computers Engineering, Informatics, and Information & Communications Technologies curricula, at the University of Trás-os-Montes e Alto Douro. As we can see from the data presented above, the students adhered to the initiative. Recall that the method used was not purely problem-based learning, but an adaptation of that kind of methodology, using experimental laboratorial learning classes, whenever and wherever possible using ICT tools and trying to move to a framework like the one proposed by Tambouris et al. (2011). We believe that these courses provided a basis for developing team skills in engineering classes and improved both student and teaching staff morale.

The methodology applied had indeed helped the students to succeed the mandatory courses. Recall that, for the first semester, 74% of the students attending the non-mandatory courses were succeeded in the mandatory courses, in contrast with the 31% of the ones succeeded but not-attending the non-mandatory courses. These numbers were even sharper for the second semester: 94% and 47% for attending and not attending the non-mandatory courses, respectively; note the increment of 20% in the number of succeeded students attending the non-mandatory courses. In our view, these better results can be mainly attributed to the extra motivation students gained when they feel they are "physically" (closely) accompanied by the specialized trainer, and they have more time to practice and solve the problems in a more "tutorial-like" and supported basis, as can be concluded from the transcriptions of the interviews presented in the previous section. Also, the contribution to the lower percentage of students giving up, missing, or that do not have the minimums required to do the final exam, and consequently fail the final exam, was higher in the group of students attending the non-mandatory courses; first semester, 8% and 52% (attending and non-attending, respectively), second semester, 2% and 23% (attending and non-attending, respectively); this is particularly evident from the interview transcriptions in the previous section. What's more, the students feel that this initiative helped them doing the "true transition" to the Bologna paradigm.

In summary, and using the students' own words, "(I) rather prefer this kind of approach (PBL), instead of more theoretical ones", "it really helped me understanding some basic facts and guiding and programming/scheduling my study", "(…) helped me to see «the big picture» (…)" and "I was really thinking quitting one or two (mandatory) courses (because of the great number of mandatory courses I was enrolled with), but the words, patience and support of the trainer stimulated me to continue and not given up".

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