EUROPEAN BOLOGNA'S IMPLEMENTATION: SHORT AND MEDIUM TERM RESULTS IN THERMAL ENGINEERING AREAS

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Abstract. *Ten years have passed since European higher education systems' Ministers formerly agreed in signing the Bologna's Declaration, thus establishing a strong commitment between EU governments in building a large educational area, improving transparency and, especially, compatibility between national systems. There is, however, an apparently minor aspect of this global issue that tends to be overlooked: the change of focus from knowledge transmission to student's competence acquisition, i.e., abandoning traditional scholarly pedagogical practices that relied on competent fulfillment of programs and formal evaluation of students. The definition of the academic and professional profiles should now be related with the identification and development of students' acquired skills; those are supposed to be the core items of the system's institutional and governmental assessment, to be eventually performed under OCDE/ENQA guidelines by a Higher Education Quality Assurance Agency (HEQAA). This paper describes the implementation of a problem based learning approach in both Thermodynamics and Heat and Mass Transfer, aiming at reaching some of the mentioned hard skills expected for competent engineering graduates. The measures that are supposed to allow for the construction of an adequate basic conceptual structure in applied situations are reported, at the same time that dealing with the need to formulate solutions to open ended problems is supposed to fill the gap between theoretical and professional areas, again skills that shall be assessed under the HEQAA. Nonetheless, almost four years later, the internal assessment that has been carried out in these courses does not show significant improvements on the average level of graduates. This paper also tries to identify the main factors affecting this perspective.*

Keywords*: Bologna Process, Problem-based learning, Thermal Sciences*

1. INTRODUCTION

Higher education, or Tertiary education, as OECD (2008a) has been recently introducing in its own Glossary of Statistical Terms, including, beyond Higher education, Further education, is undoubtedly a major concern of governments. It has been recognized as one of the major drivers for economic competitiveness in a globalised world, which has been demonstrating how education is playing an increasingly important role. Europe is engaged in improving the citizen's ability to deal with and being able to prosper in a world of ever increasing global competitiveness. The Bologna process is part of that strategy that has, with an ulterior motivation, been trying to approach the level of integration that the United States have shown to be possible to attain throughout Higher Education. The great visibility that, all over the world, US universities have been demonstrating is an asset that every other European university would like to possess.

OECD defined two types of programs: a type A, that represents heavily theory-based curricula designed to provide qualifications for entry to advanced research programs and professions with high skill requirements, such as medicine, dentistry or architecture, that must have a minimum cumulative theoretical duration (at tertiary level) of three years' full-time equivalent, although they typically last four or more years, and that are not exclusively offered at universities; a type B, that are typically shorter than those of type A and focus on practical, technical or occupational skills for direct entry into the labor market, although some theoretical foundations may be covered in the respective programs and have a minimum duration of two years full-time equivalent at the tertiary level. These guidelines have not been observed as Europe as a heavy past burden concerning the symbolic translation between longer duration higher education programs and increased social recognition. Therefore, and still nowadays not in place all over the European academia, the maximum reduction that took place was between three and five year long, with engineering graduations appearing both in type A and B programs. This is also the Portuguese case, particularly in the engineering areas, where type B programs exist in both higher education subsystems, though with a semantic distinction between polytechnics, with typical three "focused on practical and technical" years, and universities, where the program is called an 'Integrated Master's course', therefore attributing the OECD' "high skill requirements" distinction mark.

Apart from being able to enforce politically the decisions concerning this sector, the European Union has given an informal consortium of institutions the task of enforcing that policy, namely OECD, ENQA, European Association for Quality Assurance in Higher Education, and EUA, European University Association. Particularly ENQA, which was called to assess the system of the Portuguese Higher Education quality assurance, produced a report delivered by the end of 2006 (ENQA, 2006) where the systems' major weaknesses were pinpointed: limited independence, lack of sufficient operational efficiency and consistency, lack of consequences or follow-up on evaluations, lack of commitment from higher education institutions and lack of activity by the (former) Higher Education National Evaluating Commission (CNAVES).

Their recommendations were that a joint program accreditation with academic audit at institutional level, mixing different quality assurance methods, should be put in place, including both the element of control (accreditation) and the element of improvement (academic audit). Furthermore, an independent national agency for quality assurance should be established, responsible for accreditation as well as for audit processes on a one-tier basis, that should be truly independent of the government and higher education institutions, with his members appointed by government in their personal capacity on the basis of a procedure that secures representation in relation to Portuguese society and higher education institutions. Finally, to ensure a wider involvement of relevant stakeholders in quality assurance, the board should be supplemented by an advisory council with representatives of relevant stakeholders, including higher education institutions, employer organizations and professional associations (ENQA, 2006). Also, the agency responsible for the quality assessment of the system should invite international experts to bring an external perspective into a country that, nonetheless, still suffers from a certain degree of its peripheral situation in the European context.

Stepping into some more details, the object of the evaluation is set out from legal documents, namely from the Law 38/2007 (MCTES, 2007), and are: the quality improvement, the development of a quality culture and the provision of well-rounded information to the public on the performance of higher education institutions. Quality evaluation is compulsory and will take place within the framework of the European system of quality assurance in higher education. The quality evaluation will consist of a self-evaluation followed by an external evaluation carried out by "the evaluation and accreditation agency for quality assurance in higher education", HEQAA. Also, accreditation of higher education institutions and, for the existing ones, accreditation of their study cycles, is to be based on the quality evaluation and is aimed at ensuring the fulfillment of minimum requirements which will lead to the official recognition of higher education and their study programs. A considerable importance is given to the part played by the Dublin descriptors (Eucen, 2009) on the minimum requirements fulfillments.

The Bologna process has then evolved since 1999 (Bologna, 1999) and is now in a phase of implementation that allows Higher education institution to foresee, in the near future, which are the actual consequences of not complying with its major trends.

Dublin descriptors, regarding the qualifications that signify completion of the first cycle, state that the corresponding graduation should be awarded to students who:

"*1. have demonstrated knowledge and understanding in a field of study that builds upon and supersedes their general secondary education, and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study;*

2. can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study;

3. have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues;

4. can communicate information, ideas, problems and solutions to both specialist and nonspecialist audiences;

5. have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy."

This document is usually accompanied by a short glossary that enlightens the reader to the meanings of the words '*professional*' ("used in the descriptors in its broadest sense, relating to those attributes relevant to undertaking work or a vocation and that involves the application of some aspects of advanced learning; it is not used with regard to those specific requirements relating to regulated professions; the latter may be identified with the profile / specification") and '*competence*' ("used in the descriptors in its broadest sense, allowing for gradation of abilities or skills; it is not used in the narrower sense identified solely on the basis of a 'yes/no' assessment").

In 2005 the EU Commission introduced the EQF-LLL- European Qualifications Framework for Lifelong Learning, to provide a common reference to facilitate the recognition and the transferability of qualifications, based mainly on knowledge, skills and personal and professional competences (EUCEN, 2009). A conversion between Dublin's and EU's descriptors can be found in Annex 1 of the 2007 version of the document (EUCEN, 2009) and Tab. 3 below.

This paper describes the implementation of a problem based learning approach in both Thermodynamics and Heat and Mass Transfer, aiming at meeting both professional and competence hard skills embodied in the Dublin descriptors, and tries to identify the main factors that make improvements scarce.

2. CHANGING STRUCTURES - THE FORMAL PART OF THE PROCESS

Over the last twenty years, the life span of the Mechanical Engineering and Industrial Management graduation, there were several measures taken in order to give students the best education for their future professional lives such as measures concerning freshmen integration, tutorial and socio-pedagogical programs, team working projects, curricula and methodology revisions.

The duration of the different study cycles was legally established by the government for the first cycle (the former bachelor graduation) as corresponding to 180 ECTS (European Credit Transfer System Units), distributed by six semesters. This credit system takes into account all the student's work hours: classes, tutorials, preparation and lab experiments and study. The new degree has five subjects each semester, one less than the former degree. One very important change has to do with the fact that the number of hours per term has decreased substantially, from an average of 420 hours to the present 300; from the students' immediate point of view, each course had a reduction from 6 weekly hours to an average of 4, *i.e.*, a broad one-third time reduction.

This new graduation is centered in the student's need to develop the necessary professional skills, namely in areas like production, industrial maintenance and industrial management. Curricular structure is strongly based on Mathematics and Physics (Marques and Paiva, 2000). General skills, critical for professional future, such as analysis and ability to summarize, communication skills, practical and critical sense, time management and team work were also considered activities to be coached and developed throughout the course. Furthermore, the words of advice from employers that are looking for graduates are looking for those who possess: excellent communication skills; teamwork skills; leadership; computer/technical proficiency; hard working attitude.

4. THE THERMAL SCIENCES

The graduation has a set of classical courses that embodies the area of the Thermal Sciences, such as Thermodynamics, Fluid Mechanics, Heat and Mass Transfer, Thermal Machines and Combustion. It would present some considerable difficulties addressing the whole group with the same level of detail. As Thermodynamics and Heat and Mass Transfer are two very close subjects, they will be the object of the present analysis.

4.1. Some common aspects

There is a common ground between the two courses and that common ground expresses the efforts that have been made to meet the prevoiusly stated expectations, namely those that concern the Dublin descriptors. But also some extra features that are the result of an acquired pratice and that, though without representing major breakthroughs in changing the outcomes, are the expression of the belief from faculty that there is no process of learning more studying less.

Some of the common features are:

i) On average, 3 out of 6 ECTS are used in oral classic exposition, using OHP transparencies and power point slides, as well as the board to illustrate practical cases and exercises; approximately 2 ECTS are used with applied examples and questions and doubts related with that week's assignments. A minimum of 4 hours are dedicated to tutorials (extra classes), including a Wednesday free afternoon.

ii) Obligatory 75% of class attendance; teams of 3 students are formed, voluntarily during the first two weeks, under the instructor's decision by the end of the third week.

iii) Self-grading: assignments, mostly exercises, are delivered by email every Friday evening; usually Saturday morning, again by email, the instructors handwritten complete and explanatory solutions are provided (Plett and Peter, 2007).

Course -	TCM				
Team - 3	Bruno Fonseca (8410), Frederico Ferreira (6843), Paulo Cabral (5728)				
	Hélder Bernardo (8072)				
Assignment/Project -	kiln insulation				
Date - 070509					
	#1	#2	#3	#i	
1 - Technique					%
1.1 Summary		2			2
1.2 Introduction: content & importance		3			10
1.3 Detail & logical structure		2			4
1.4 Visual aids quality		2			4
1.5 Understanding	5	5	4		10
2 - Presentation					%
2.1 Objectives		1			2
2.2 Knowledge	5	2	4		15
2.3 Audibility	3	3	2		5
2.4 Visual aids clearness		5			10
2.5 Rigorous use of time		10			10
2.6 Posture	2	1	2		4
2.7 Sensitivity to the audience	1	0	2		4
2.8 Answers and comments	3	1	4		10
2.9 Effectiveness of presentation		4			10
	48	40	46	45	100
Comments -					
COMENTÁRIOS BIS!!!					
Não houve indicação da estimativa da energia armazenada na gravilha					
"Este ângulo foi determinado experimentalmente(…)"- como?!!					
Dicção Hélder					
Justificação do ângulo em função das dimensões interiores					

Figure 1. Sample grid of the evaluation of the student's teams presentations.

iv) Assignments delivery: assignments are due, self-graded, every week, within a week; they must include a short, comprehensive explanation on the difficulties faced, enabling instructor's follow-up. When approaching ¾ of lectures, some of the exercises sent, normally 1 out of 3, have no accompanying solution, thus enabling to identify committed followers. Instructors willingly try to help students to make their own way through the resolution, though never solving that particular exercise or problem (Mazur, 1997).

v) Problem-based learning: from the first day of classes, a list of open-ended problems is delivered or a specific one is proposed with several concurrent approaches; teams will have three weeks to sort it among them. These tasks usually involve some lab work, not previously defined but arising as a consequence of problem solving.

vi) Every two weeks, in the last class of that week, progress reports are delivered to the class in a presentation format; evaluation grids were prepared for the assessment of presentations and an example is presented in Fig. 1 (Paiva, 2003).

There are items that are common to all the team members (1.1 to 1.4, 2.1, 2.3, 2.4 and 2.9), *i.e.*, that are typically a team responsibility as a whole, and there are items that engage each member individually (knowledge, audibility, answers to questions from the audience, for instance).

4.2. Applied Thermodynamics

An overview of the contents that were obligatorily addressed when the graduation's cycle of studies was submitted to the Higher Education registration department is presented in Tab. 1. Applied Thermodynamics, though now with the "applied" qualification, keeps having an intrinsic strong conceptual and structural nature.

Table 1. Required data to registration/accreditation of study cycles: Applied Thermodynamics curricular unit.

Course	Program	Competences	Professional work
Applied Thermodynamics	Introduction, Concepts, Units and Definitions Thermodynamic Properties First Law for Closed Systems First Law for Open Systems Second Law and Entropy Second Law for Closed Systems Second Law for Open Systems Power and Refrigeration Cycles Gas Mixtures and Air Conditioning	Calculating energy balances and identifying changes that take place in closed systems (tanks, compartments, systems) Idem in control volumes (valves, compressors, turbines, pipes) Operating steam power, refrigeration and air-conditioning cycles Thermal designing plants and selecting equipment Using measurement and calibrating devices	Energy production Refrigeration Thermal behavior

4.3. Heat and Mass Transfer

Heat and Mass Transfer, though being in direct contact with the precedent contents of a thermodynamics course, has a more tangible, 'physical' nature and, therefore, can be more directly driven into practical issues. Again, an overview of the contents submitted to the Higher Education registration department is presented in Tab. 2.

Table 2. Required data to registration/accreditation of study cycles: Heat and Mass Transfer curricular unit.

Course	Program	Competences	Professional work
Heat and Mass Transfer	Introduction, Basics of Heat Transfer Heat Conduction Equation Steady Heat Conduction Transient Heat Conduction Fundamentals of Convection Forced Convection Natural Convection Fundamentals of Thermal Radiation Radiation Heat Transfer Mass Transfer	Identifying and analyzing transfer phenomena Insulation dimensioning Applying thermal behavior regulations to specific cases Using measurement and calibrating devices	Heat Transfer and Combustion Thermal behavior of buildings

5. PROBLEM-BASED LEARNING

5.1 (semi) Ill-Posed Problems

A formal sheet of paper containing the proposed subjects for that term's activity or activities is distributed among students attending the first class of that term and a general discussion is engaged under the instructor's supervision that draws the boundaries for the activities, namely those concerning budget issues.

Figure 2. Sample PBLs on "Why is Thermodynamics Applied?"

1. The heating system of hot water of a spa needs to be replaced. The current system consists of two mural boilers (one for the male spa, the other for the female) and the goal is to replace it for a solar energy system. 50 baths per hour are taken in each 1 hour period each day of classes. One bath takes an average 5 minutes, with the particularity of the baths being taken in the last 10 minutes of the period. How shall the system be designed (capacity of the reservoir and area of the thermal solar panels, among others)?
2. A wine cooperative needs to follow the new trend wineries and make the fermented mash at a low temperature of 26º C. As this is an activity that takes place by the end of the summer, beginning of autumn, is not unreasonable to expect that in the months of September and October temperatures around 35º C can take place. If the mash is inside a cylindrical vessel with a 1.8 m diameter and 4 m height, which features should have a machine that allows withdrawing some 200 W/m3 of energy that are released during this process, while maintaining the desired temperature of fermentation?
(...)
8. Your future employer tells you that you need to design a system to convert from biomass (which is the industry term used to describe the fuel obtained directly from trees and plants). This system should be able to provide the thermal and electrical energy sufficient for the inhabitants of a single house. What is your response to this challenge? Which engineering proposals can be made? How much fuel will be needed? Please note and explain all the steps you take, indicate clearly all the assumptions made and consider 15,000 kJ/ kg for the HHV of the biomass.

Figure 2 has some examples of subjects proposed in the curricular year of 2008 in Applied Thermodynamics. Similar problems are proposed on Heat and Mass Transfer or, as in this 2009's curricular year, a sole problem, with multiple concurrent approaches can be proposed. In both cases, teams are obligatory and a leader/coordinator of each team is indicated by the students or appointed by the instructor around the third week of classes. Instructor has the possibility of destitution the team's leader if he or she fails attending more tan two consecutive meetings, usually made on Thursdays or Fridays afternoon. Those are approximate one-hour reunions, taking place to discuss issues arising from the development of the activities and to monitor and track progress of previously defined milestones, and are irreplaceable in maintaining (and sometimes adjusting) timelines. Another decisive aspect of these weekly reunions are that they provide a common ground of knowledge and transfer important information and suggestions from all coordinators, thus increasing the likelihood of meeting the established goals. Two afternoons were available to the whole teams to meet the instructor in the lab facilities.

In 2006/2007 a problem was posed concerning a MacDonald's fry: "Do you think you could improve McDonald's fries and to deliver a textbook to successfully fry the best French fries?" The discussion on what was a good French fry began, and after a while the good fry was defined as a simultaneously interiorly baked and externally crispy fried regular sized piece of potato. Students were assigned to search for more detailed information on that subject and to give an oral presentation during the next class. Meanwhile, the problem proposed was, in order to bake a piece of potato with the same dimensions as the French fry, to investigate the possible use of the Lumped System Analysis. Next, some convection fundamentals were taught and students used them to look into the subject and eventually calculate, by means of a semi-empirical correlation, an approximate value of a natural convection coefficient. This subject was worked on until the end of classes. It was the anchor of the remaining topics; it was used to address bi-dimensional conduction, to use the Heisler and Gröβer charts (Incropera and DeWitt, 1996), to deal (and understand the attractiveness of that usage) with semi-infinite solids, to calculate different convection heat transfer coefficients to cope with the fact that a rectangular prism like fry, has horizontal and vertical panes; to simulate fin behavior, with the same dimensions, exposed to a high temperature fluid.

A request from the Electrical and Electronical Department to assist on one of his student teams on the best way to ensure a proper sequence of temperatures inside an oven where a printed circuit was to be thermally treated/cured was the starting point for the 2007/08 PBLs. Finally, in the present curricular year, an ongoing project EU funded on biomass for energy that needed the assessment of a region's specific shrub drying ratios occurring using solar dryers led to the solar kiln PBL**.**

5.2 Experiments

Applied Thermodynamics has been using good lab equipment available and experimental activities involving the use of refrigeration equipment, as well as HVAC, are common. Energy conversion by means of a small vapor power cycle plant is one of the most popular experiments. Many theoretical results are compared to experimental data gathered with a data acquisition system. Teams are allowed to perform experiments only after succeeding at an oral examination (Lopes *et al.*, 2007).

The level of integration achieved with these experiments is clearly lower than the one described below for Heat and Mass Transfer. In this case it was possible that, when dealing with the French fry issues, and after realizing that vegetable oil was not an electrical conductor (through an internet search were a German student was proving the point by totally immersing a motherboard into an aquarium filled with vegetable oil), a specific, on-purpose experiment was put in place. The analysis of the results made showed that a serious effort was made to link observations with theory. For instance, when a significant superficial temperature decrease was registered, in comparison with the data being recorded by the inner thermocouple of Fig. 2, led to the recognition of the latent energy used for phase change as water inside the potato was evaporating at the surface, merged into hot oil. The natural convection hot horizontal surfaces hexagonal pattern, which description was always a bit "fluid", was identified during the frying experiments (Fig. 2). The transient heating process of the electric frying pan was also used to determine electric consumption and the amount of energy needed to fry 500 g of initially frozen potatoes.

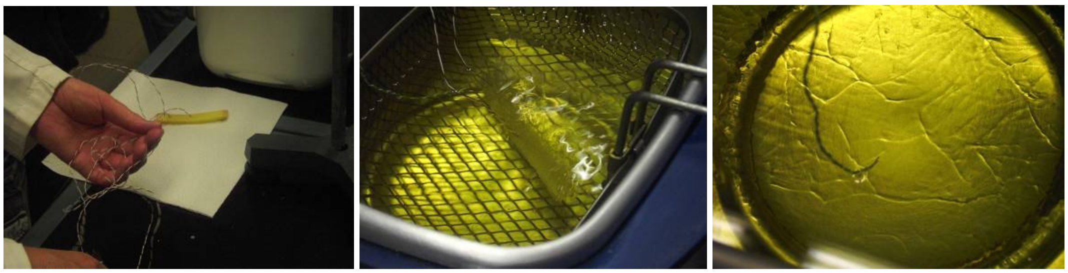

Figure 2. Wiring and frying the French fry (upper surface of a hot plate, natural convection).

In the end, the data was compared with the theoretical results, in order to assess the amount of time needed to bake and fry the potatoes. And though this was an atypical situation, the order of magnitude involved was quite satisfactory.

Figure 3. Wiring and preventing the thermocouple from direct exposure to radiation; IR emission.

The thermal treatment was intended to make the resin over the printed circuit experience a temperature value evolution pattern that would cause a pre-heat, soak, reflow and cooling sequence, all of them within very tight time intervals. Different heating electrical resistances were tested inside a small lab furnace and the internal air temperature evolution data acquired to assess if the required conditions were being met.

Figure 4. Solar kiln designed to dry 60 kg of local shrub species.

The solar kiln project that led to the design, construction and test of the device shown in Fig. 4, can be more thoroughly appreciated accessing the site/blog created to display all the phases of the process, as well as the team's own explanations on the way they tackled, interpreted and solved some of the difficulties encountered (TCM, 2009).

5.3 Follow-up

For all the works in progress, every two weeks a file containing the corresponding presentation's report is sent by email to the instructor by the team's leader. The document is evaluated on substantial issues but also on the formal observance of Reports and presentations rules, namely those concerning the structure "Title, Summary, Table of Contents, Introduction, Analysis, Procedure and Results, Discussion of results, Conclusions and References".

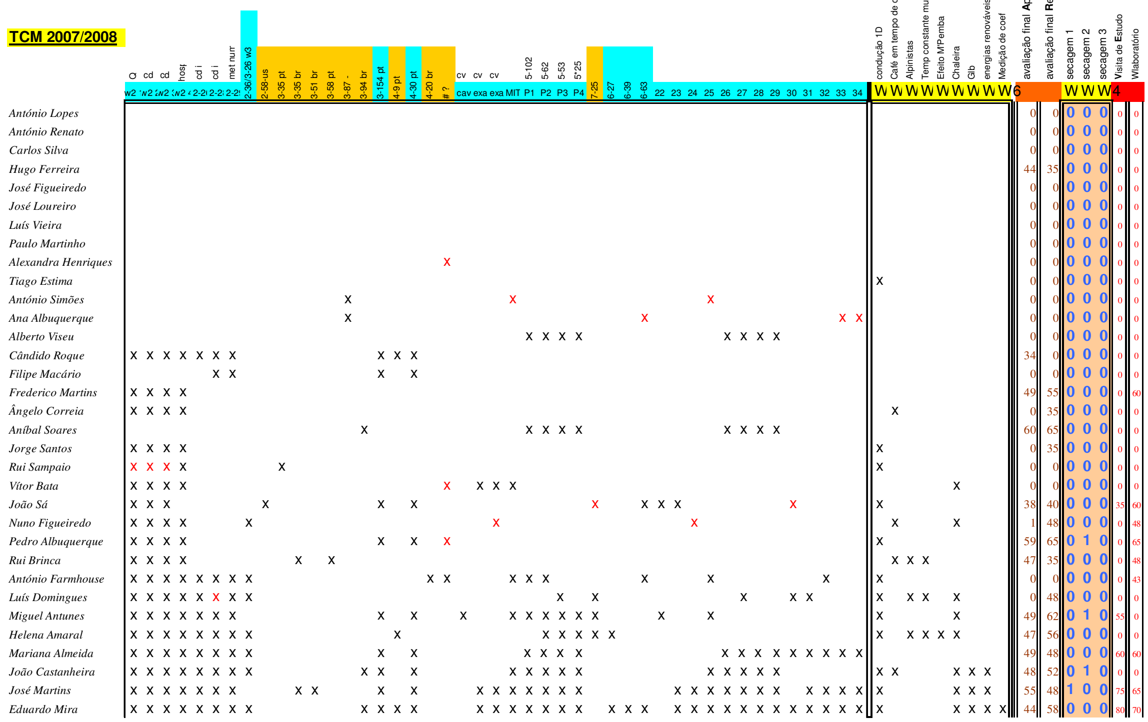

Figure 5. Truncated sample of one list of continuous evaluation for one shift.

As for the follow-up of self-graded assignments and, if it applies, lab work and guided visits reports, it takes place every two weeks. A file (like the one presented in Fig. 5) is emailed to all students so that they can check the accuracy of the data displayed, namely on what concerns the exact number of assignments delivered. It is called by students the "debtors' list" and, quite surprisingly, is a major factor in keeping a wealthy pressure on on-time delivery (also because only one week late is tolerated and the corresponding assignments marked in red and 50% depreciated).

5 .4 Formal evaluation

Figure 6 evidences the common structure used in the formal evaluation of this area:

Questions 1 to 4 are the kind of questions that can be found on Fundamentals of Engineering (FE) exams and are multiple-choice questions that address a maximum of two consecutive steps in the solving process. They are intended to evaluate the acquired 'knowledge', a learning target that can be considered to be composed by the acquisition of facts, concepts and theories. In the process of preparing these multiple-choice questions, a selection is made by the instructors on which subjects they want to test the student's knowledge acquisition. Additionally, being numerically based quizzes, they also address and enforce the need to accuracy in results, which is fundamental to reincorporate in the learning process too often exclusively focused on reasoning. This part of the evaluation also aims at rewarding knowledge, comprehension and application obtained by means of regular study in class. The weight on the test's global measurement is of 40%. Questions 5 and 6 are usually conceptual questions stressing the importance given to understanding the physics of processes (the kind of those presented in Fig. 6: "Should you face the choice from where a compressor must aspire air from, the plant's internal or external facilities, which one would you choose and why?", "Do glasses get blurred entering or leaving a café in winter and why?" and "If a tube insulation, which thickness is such that the insulation radius is smaller that than the critical radius, is removed, the rate of heat transfer will increase?"), try to evaluate the 'reasoning' learning target by questioning the conceptual understanding of common domestic and professional daily phenomena. It can be found in many text books (Çengel being the author that deserves the largest part of that particular credit). They account for four points, *i.e.*, 20% of the overall mark.

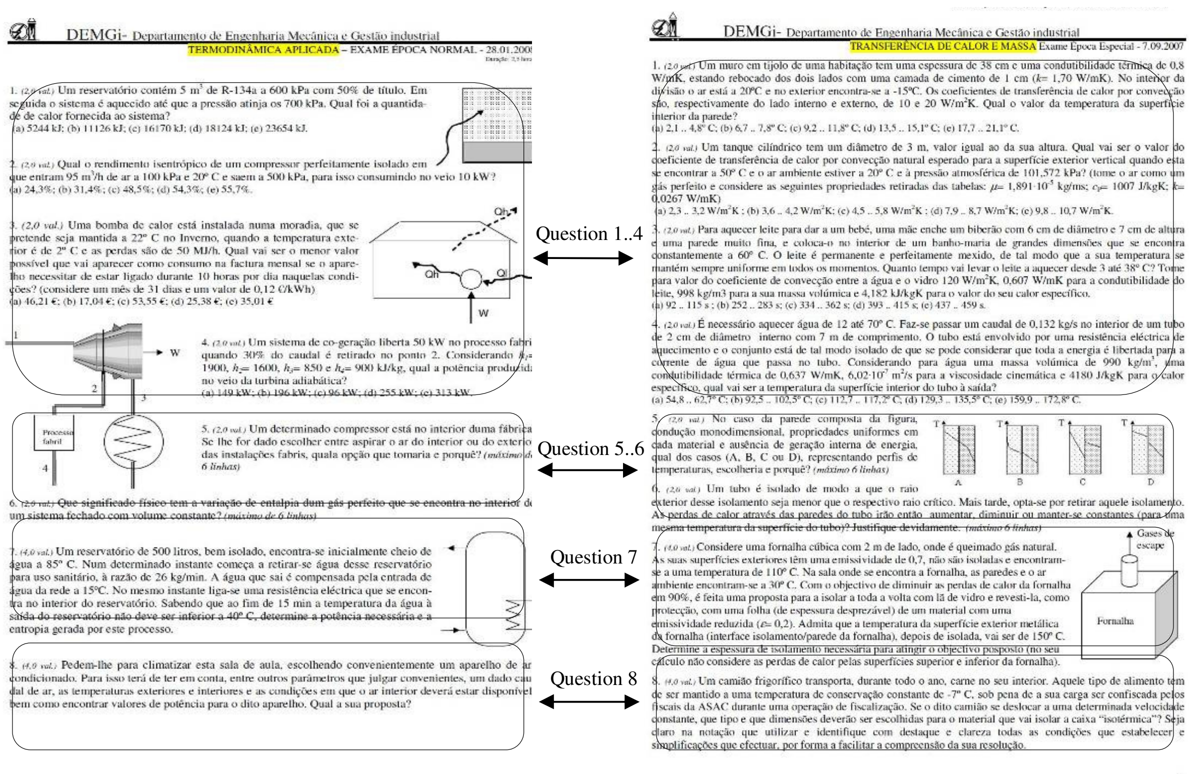

Figure 6**.** Examples of test's structure of App. Thermodynamics (ATD, left) and Heat & Mass Transfer (HMT, right).

Question 7 is the traditionally 'problem', in a sense that this kind of question will be the object of a 'constructive' correction, giving a good deal of credit to developing reasoning and not only the final result. They are worth 20% of the final mark and can address both second and third Dublin's descriptors.

Question 8 is intended to provide an insight into the results obtained in the assessing, mainly, the third and the fifth descriptor. In most of the occasions, these were questions that closely replicated, though not formally, the issues that were dealt with in PBLs. For instance, when the French fry case was developed, twice the question 8 of that year's exams addressed situations where both the required knowledge and the geometry were close to transient heat transfer in large plane walls' case, using data previously acquired by a data system; with the solar kiln, questions were related to decisions on and logical concatenation of data and steps that would be needed to pre-design drying equipments.

6. RESULTS AND DISCUSSION

The results of three consecutive years in applying the described set of pedagogical operations, from an assumed formal point of view, *i.e.*, using the tests results for the two courses over curricular years of 2006/07 to 2008/09, is observable on Tab. 3.

Table 3. Discrete results for Applied Thermodynamics (ATD) and Heat and Mass Transfer (HMT).

Test question #	Descriptors		2006/2007 (%)		2007/2008 (%)		2008/2009 (%)	
	Dublin	EU	ATD	HMT	ATD	HMT	ATD	HMT
			99[a]	106[b]	119[a]	91[b]	120[a]	82[b]
1..4	1 2	1, 2, 3 3, 4	27	35	32	28	17	n.a.
5, 6	3	10, 11, 12	32	23	7	30	18	n.a.
7	2, 3	3, 4, 10, 11, 12	20	4	10	17	22	n.a.
8	3, 5	7, 10, 11, 12	7	21	19	12	13	n.a.
Success rate$_{tests}$ (%)			17	18	20	12	11	n.a.
Success rate$_{final}$ (%)			17	16	19	12	11	n.a.

([a]): number of students evaluated in Applied Thermodynamics
([b]): number of students evaluated in Heat and Mass Transfer

There is nonetheless an exception: 2008/09 for Heat and Mass Transfer, as it is a course offered from the end of February till the end of May 2009. The values presented are the average of three evaluation seasons for each curricular year, one designated as "normal", a second one of "appeal" and one extra. These are seasons routinely inscribed in the internal pedagogical regulation of the Polytechnic and a common situation in all the Portuguese higher education institutions, but they do not appear to be a good practice: regular studying students are not rewarded and success results do not increase by this sole fact.

It is worth mentioning that the decrease in the number of evaluated students in Heat and Mass Transfer is the result of the change that occurred in the curriculum of the Mechanical Engineering graduation, from the second to the third year, on one hand, and, on the other, to the fact of being a course that is not available in the Industrial Management graduation, situation that does not occur with Applied Thermodynamics, obligatory in the second year of both graduations. To give a more proximate insight into global results, line "Success rate final" represents the overall success rate as it includes both tests results and continuous evaluation resulting from home-work assignments, attendance quality, PBLs, presentations, laboratory works and reports from guided visits; having both components mandatory minimum 9.5 points over 20, the final success rate has to be lower than the tests one.

That being said, the first unavoidable conclusion is that the overall results are far from being good. The only reason why they are not considered unacceptable is related to not having effectively in place a regime of a limited number of possible inscriptions. Actually, there is one but, for political reasons, it is still under a prorogation status; it is supposed to initialize and to produce effects by the end of 2009. Until then, many of the students inscribed will keep on either not attending classes at all or attending but not working sufficiently. The fact is that there is a strong individual correlation between students that present good average results in Fig. 5 control sheet and final success in both courses. This is a clear indication that continuous work and commitment are key factors to succeed and need to be enforced and "internalized" by the student's culture and the sooner the better.

In what concerns the evaluation of the Bologna process effects, by means of this probably controversial method, the results show that they seem far from being acquired. Particularly those skills and competences that question 8 was intended to test for, are showing a sensible divergence between the expectations and the outcomes. Question 8 addresses clearly the EU tenth descriptor, for the second cycle of studies (though at the seventh reference level): "Solve problems by integrating complex knowledge sources that are sometimes incomplete and in new and unfamiliar contexts" (EUCEN 2009). And that does not seem to be happening. Some say that one of the problems in engineering today is the tendency to promote students based in their skills for math and physics whilst showing unconcealed contempt for recognizing or encouraging the one skill that engineering is all about: making things (Marriot, 2009). In the case of these two courses, attempts were made to reach that status but the results are not forthcoming.

7. CONCLUSIONS

The results of the formal part of the evaluation are not encouraging, especially if short term results are to be assessed. Nonetheless, looking ahead there seems to be no other way than continuing making efforts to support that kind of ambitious desideratum that mixes knowledge, skills and autonomy, responsibility, professional and vocational competence. One of the problems that must be addressed is the fact that students understood the Bologna changes as if it was a way of easing their academic career lives. The reduction of the number of classic class, contact hours between the instructor and the students, turned that initial sensation in something solid from most of the students' unconscious point of view.

One of the main issues regarding the reshaping of higher education in Europe is the assessment of the outcomes in terms of improved quality, that can be defined as "the process of establishing stakeholder confidence that provision (input, process and outcomes) fulfils expectations or measures up to threshold minimum requirements" (Harvey, 2004-2009). This will be probably the stage at which the verdict will have to show a clear-cut: either lowering standards to meet efficiency ratios or keeping on with a rigorous approach to guarantee improved quality of knowledge, skills, personal and professional competence.

An old professor used to say: "Easy school, difficult life." Is it still true?

8. REFERENCES

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