Course design approaches for the EHEA

Scaling up from pilots

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Abstract— **After years of preparation and limited-scale pilot projects, full blown implementation of European Higher Education Area (EHEA) compliant degrees started in 2008 at the UC3M. This paper discusses the final stages of preparation, as well as the initial lessons from this go-live experience, focusing on a core (compulsory) second year subject of the computer engineering curriculum whose full-scale implementation started in 2009. Lessons drawn from the preparatory pilots are presented, implementation challenges are identified and analyzed, and both school-level and course-level required design approaches are discussed. Conclusions highlight that successful adoption of some critical elements of the EHEA methodology in the Spanish engineering education environment is far from certain.**

Keywords- Bologna, EHEA, course design, curriculum development

I. INTRODUCTION. EHEA ADOPTION IN SPAIN

The 1999 Bologna Declaration, currently endorsed by 46 countries, aims at the creation of a European Higher Education Area (EHEA) based on international cooperation and academic exchange [1]. It involves major reforms in the higher education systems (as well as an alignment processes with the European Research Area), including: Common adoption of a three-cycle structure (e.g. bachelor-master-doctorate); Quality assurance in accordance with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG); Fair recognition of foreign degrees and other higher education qualifications in accordance with the Council of Europe/UNESCO Recognition Convention.

In Spain, the first EHEA-compliant bachelor degrees started in September 2008, among substantial controversy. 33 Spanish public and private universities, out of the 75 existing ones, offered 163 programs. By Sept 2010, all bachelor degrees must be EHEA-compliant.

The Bologna Process Stocktaking Report 2009 [2] analyzes and compares, using various criteria, the current implementation status of participating countries, and Europe as a whole. More specifically, the Spanish National Report compiled by the Spanish Government in 2009 discusses in detail the current status of EHEA adoption in Spain [3].

The Spanish National Report analyzes the evolving regulatory framework within which EHEA implementation in Spain is taking place. This framework encompasses Royal Decree 56/2005 of 21st January, on official postgraduate studies. This Decree, later superseded, created a temporary legal base which led to the first EHEA-compliant postgraduate degrees, even though no EHEA-compliant undergraduate degrees (the natural source for candidates) could still be offered. The current regulatory framework is largely determined by Royal Decree 1393/2007 of 29th October, which regulates the organization of official university education and develops the new structure, encompassing:

- First cycle (Bachelor). According to EHEA agreements it could range between 180 and 240 ECTS; in Spain it has been standardized at 240 ECTS credits, equivalent to 4 years of full time study.
- Second cycle (Master's) studies, ranging from 60 to 120 ECTS credits.
- Third cycle (Doctoral) studies lasting between 3 and 4 years.

Royal Decree 1393/2007 defines 5 broad "branches" for undergraduate degrees: Arts and Humanities, Natural Sciences, Social Sciences and Law, Health Sciences, and Engineering/Architecture. Each undergraduate degree must be ascribed to one of these branches and must include at least 60 ECTS of "basic" courses. At least 36 ECTS of these "basic" courses should be on the topics listed for the degree's branch. For example, any Engineering/Architecture degree should include at least 36 ECTS credits from physics, mathematics, computer science, business administration, graphical expression (i.e. technical drawing), and chemistry [4]. No content guidelines were specified for master's level degrees in order to encourage universities to foster their unique specializations. Special degrees such as Medicine should be regulated separately from other degrees. Those degrees requiring certification for professional licenses such as engineering require additional content guidelines; however, these additional guidelines were not prescribed in R.D. 1393/2007; for engineering degrees, were only issued in February 2009, as discussed below.

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Royal Decree 1393/2007 also replaced the previous government-approved closed catalogue of official engineering degrees by an open-ended evaluation and accreditation process whereby each university could propose whichever bachelor degrees it deemed appropriate. Therefore, these 163 new degrees were, for the first time, designed without a government-provided template.

II. CURRICULA DESIGN AND APPROVAL

The public university Carlos III of Madrid (UC3M) was the only one to embrace a big-bang conversion approach, proposing a simultaneous replacement of all its existing engineering degrees by the new ones. After completing the Quality Assurance review (ANECA), 80% of these proposals were approved by the education authorities, thus, in September 2008, 8 out of its 10 undergraduate engineering degrees were discontinued, and replaced by new offerings conforming to the new cycle structure, credit transfer system and pedagogical and assessment approach. The two remaining ones, which were particularly affected by unsettled elements of the regulatory environment (specifically, professional licenses granted at the master's level) will be transformed in September 2010.

This meant that all UC3M engineering degrees were simultaneously redesigned. Furthermore, as previously discussed, the curricula for these degrees were, for the first time, designed without a government-provided template, subject solely (since they all belonged to the Engineering/Architecture branch) to the stated prerequisites on the 60 ECTS of "basic" courses, encompassing 36 ECTS credits from "basic" subjects.

This created an opportunity to exploit synergies between degrees [5]. In some cases, such as the Univ. Europea de Madrid's Health School, the gradual (and, therefore, only partial) conversion to EHEA of related degrees has delayed the materialization of these synergies, while on the other hand it has provided the opportunity to gain from the experience of the first ones to undertake a full conversion (e.g., better understanding of the potential of IT support tools, such as anti-plagiarism tools). In the school of engineering of the Carlos III University, the first two years of degrees belonging to the same "family" (industrial, telecom, computer science...) will be identical, to allow for built-in flexibility for late career path changes as well as resource pooling in areas such bilingual groups. Furthermore, the February 09 decrees, that established additional content guidelines for regulated engineering professions requiring professional licenses, imposed "family modules" (i.e., "Módulos comunes a la rama industrial"), that all degrees of the same family must include in their curricula, in addition to the basic branch-linked subjects. Since these additional guidelines were issued when the corresponding bachelor degrees were already being offered at the UC3M, some "retro-fitting" has been performed on the curricula – and sent back to the education authorities for approval - to ensure they conform to the guidelines.

Implementing these changes while the degrees are already being taught complicates the process further. At UC3M, complying with the guidelines has often merely required minor content changes in various course descriptions, but in a few cases it has forced to introduce new courses (and delete others). Since the new degrees started in September 2008, and the new guidelines were published in February 2009, these changes are being located in the curriculum, whenever possible, not earlier than the second quarter of the second year, so that the first cohort of students had not taken these courses yet. As an example, the subject discussed in this paper, Foundations of Engineering Management (FEM), had to be moved, in three degrees, from 4th year to 2nd year. In some of these, it might have been preferable to locate it in the first term. However, since students would be attending the first term of the second year by the time the proposal would be approved, they were all assigned to the second term.

This issue is also complicated by the coexistence of professional licenses that require a bachelor degree and others that require a master degree. As an example, a bachelor in electrical engineering will be entitled to sign electrical projects. A bachelor in mechanical engineering will be entitled to sign mechanical projects. However, if either of them goes on to complete a masters program in industrial engineering, he/she will be entitled to sign both electrical and mechanical projects.

These changes also led to the creation of some subjects, corresponding to the list of the Engineering/ Architecture basic topics, which spanned all the engineering degrees. The subject analyzed in this paper, Foundations of Engineering Management, implements the "business administration" basic topic, and spans 7 different engineering degrees, from Telecommunications to Mechanical Engineering.

Regarding methodology, the Bologna process was supposed to involve a significant shift from instructor-centered "teaching" to student-centered "active learning". This necessitates methodological changes such as implementing continuous evaluation schemes, de-emphasizing theory-only lectures, developing assignments and class projects, and encouraging hands-on experiences. It should also allow the students to design their own curricula with a higher level of flexibility.

III. PREPARATORY PILOTS. LESSONS DRAWN

In preparation for the full-scale implementation, the UC3M and specifically its School of Engineering has been experimenting, learning and paving the way for these pedagogical changes while the legal framework was being finalized. Some groups were created for testing purposes and some degrees were chosen to extensively test out the new methodologies. The UC3M has funded a number of methodology adaptation projects and faculty training. New metrics for evaluating the faculty performance and a support infrastructure for the new pedagogical approaches have been developed. New computer tools, deemed more appropriate for the new environment, were sourced and tested (Moodle-based LMS, Turnitin© ...).

In anticipation of this full-scale implementation, the group involved in the project presented in this paper has gradually introduced, in the last few years, various elements of the methodology in lower-volume courses in existing degrees, and various approaches have been tried and evaluated in terms of their effectiveness and their scalability.

The EHEA-compliant Master in Engineering Management and Logistics, established under the provisions of Royal Decree 56/2005 and coordinated by one of the authors, has become an integrated testbed. Since its inception in 2006, all its subjects have been taught following the Bologna approach: approx. 50% of the grade is based on continuous evaluation, attendance is compulsory, emphasis has been shifted from lectures and theoretical examinations to individual and group assignments, number of lecture hours per ECTS has been reduced while workload has been concentrated in the student preparation, etc. This has provided valuable insights into the potential learning effectiveness of these approaches, but has also highlighted its difficulties and the risk of the instructor's workload exploding out of control, particularly in terms of grading assignments. Care must be exercised, however, while extrapolating these experiences to undergraduate courses, since Master students have a different, more mature profile and their number has been capped at 20.

To get some insights from student groups that are more similar to the undergraduate courses in which EHEA is initially being fully implemented, partial pilots have also been carried out in various student groups of the existing undergraduate degrees. Several English-based groups (where the institutional framework is more flexible, since students can always opt out into a Spanish group) have tried compulsory attendance, continuous evaluation and emphasis on homework assignments. In the last three years, four of these courses have been taught by foreign professors coming from institutions that routinely apply Bologna-like methodologies, and the results and the acceptance by the Spanish students has been closely monitored (with mixed results). Student reaction seemed to be heavily influenced by the specific profile and attitude of the professor involved, and his ability to positively engage the class. In all cases, however, there were complaints by students that could not attend the sessions and were therefore penalized. Three university sponsored pilots (one of them still running) have focused on improving teamwork and communication tools in a problem-based learning environment, making extensive use of interaction tools (such as electronic forums) and migrating to the web platform (Moodle based) on which the new degrees are supported.

These various pilots have confirmed the pedagogic potential of the "Bologna process" student-centric, outcomes-oriented methodologies. They have also, however, highlighted the significant hurdles must be overcome for their effective adoption in the Spanish engineering education environment, particularly when budget constraints are taken into account. Tackling these difficulties requires achieving the educational equivalent of the current manufacturing trend towards "mass-customization", in order to allow individually tailored learning paths with a level of resources similar to that required by standardized education.

These difficulties include:

- Resource requirements vs. availability. Pilots have highlighted the risk of the instructor's workload, particularly grading assignments, bursting out of control. On the other hand, and even more so considering the current economic climate and the sore status of the public finances, these reforms are generally being implemented under a "zero net additional resources" policy. That limits the approaches that can be implemented. "Craft-like" approaches that can be effective in the shift to a more active, participatory and student-centric methodology in smaller subjects can not be applied within existing resource constraints. Preliminary pilot results suggest that, unless course designs (and, particularly, evaluation procedures) incorporate elements specifically aimed at allowing scalability, these approaches can not be properly implemented with the current resources. Besides the need for additional resources, in some instances the need is for different resources, such as smaller, multi-functional classrooms, in which students can be rearranged in several working groups.
- Assessment process and motivation. This challenge relates to both instructors and students. Professors are evaluated and compensated according to their research output ("publish or perish"), with teaching being treated as a necessary evil. This complicates the implementation of pedagogical approaches that place heavy demands on their time and energy. As for the students, a substantial cultural and attitude shift towards assuming responsibility for their own development would be required, and it is not clear how to bring about this major change.
- Continuous evaluation. Conventional, individual written exams allow a reasonably accurate, fully individualized evaluation, which is hard to attain in a continuous evaluation environment, particularly if faculty resource constraints are taken into account.
- Consistency assurance. Guaranteeing a reasonable level of commonality in course contents and grading standards is harder to achieve in a proactive, student centered learning environment, where the learning is based to a substantial extent in a two-way interaction among the students and the instructor.

IV. GOING LIVE. COURSE DESIGN APPROACHES

To discuss the go-live experience, and therefore the implications of scaling up from the pilot experiences, this paper will focus primarily on the implementation project of a core (compulsory) second year subject of the computer engineering curriculum.

As discussed above, the potential synergies created by the simultaneous redesign of the various engineering curricula led to the creation of some subjects, corresponding to the list of the Engineering/ Architecture basic topics, which spanned all the engineering degrees. The subject analyzed in this paper, Foundations of Engineering Management (FEM), implements the "business administration" basic topic, and spans 7 different engineering degrees, from Telecommunications to Mechanical Engineering. This being a core (not elective) subject, this will result in a large number of parallel groups being taught in any given academic year. Since the implementation of these

undergraduate degrees started in September 2008, and this subject is taught in the 2nd year, teaching started in September 2009 in 1 degree (Computer Engineering), and is scheduled to start in six more in the second quarter of this academic year (Feb. 2009). It may also be extended to the remaining existing degrees once they are converted, as well as to new degrees.

Designing the syllabus and teaching approach of new courses such as this requires taking coordinated design decisions at various levels. Decisions affecting the institutional and regulatory framework, as well as those involving shared physical infrastructures such as classrooms, must be taken at the University or School level.

A. Design decisions taken at the University or School level

Decisions taken at the UC3M or School of Engineering level include:

- Institutional framework for assessment procedures. University-wide guidelines governing continuous evaluation have been issued. A minimum of 40% of the grade has been allotted to continuous evaluation, with no minimum thresholds for either the continuous evaluation or the final exam. Attendance to laboratory sessions, however, can be made compulsory. Detailed provisions have been made for the case in which students do not attend the continuous evaluation; their final grade will be 60% of the final exam grade, even if for that particular course continuous evaluation accounts for more than 40%. Similar provisions apply to the "extraordinary", make-up evaluation that takes place in June-July for students that received a "fail" grade.
- Small groups for practical sessions. Each 6 ECTS subject involves, each of the 14 weeks that make up a semester, a 90 minutes large-group lecture for up to 120 students and a 90 minutes small-group session, in which each large group is broken up in 3 smaller groups. Evaluation takes place in the small groups. This is aimed at allowing a small group setting where interactive methodologies can be applied, while containing the overall cost impact.
- Multifunctional classrooms. The small-group sessions take place in smaller classrooms, specifically equipped to allow different seating layouts, including breaking up into small 6-member teams.

B. Design decisions taken at the course level

The lessons learnt from the previous pilots (discussed above), as well as the actual experience of those departments whose courses are located in the first year, and had therefore already faced these issues last year, was taken into account while designing the approach implemented in FEM this first quarter. This quarter's implementation experience, in turn, is being closely monitored in order to fine tune the approach for the second quarter and for subsequent years, as well as to serve as a basis for the design of subsequent courses by the same team. Furthermore, some of the approaches being piloted in this course will be presented to the management of the Engineering School, to analyze the potential of a wider implementation.

While incorporating all these elements into the actual design of the FEM, some detailed but nevertheless relevant additional issues arose. Several of them concerned the coordination of the small groups.

Splitting the large groups into several small groups requires that the course content is consequently divided in the components that can best be taught in a traditional lecture format and those that benefit from the interaction that smaller groups allow. The methodology for the small group sessions must also be defined. A sensible approach would be to use the weekly large group session to explain theoretical contents and use the other small group session to carry out practical exercises, case discussions and other activities that engage students in an active learning model. That was the rationale behind the two 90-minutes weekly sessions design decision.

That is, however, more easily said that done, since it creates a number of coordination hurdles:

- Large group-small group sequencing. Since practical sessions apply theory that must have been previously taught at the large groups, a precedence condition is created. Bank holidays affecting some sessions but not others alter this balance. Furthermore, actual experience during the first quarter highlights how otherwise minor alterations of the normal schedule become far more disruptive under this schema, e.g., time lost at some groups due to a student delegate election or to student satisfaction surveys.
- Weekly coordination among instructors in large and small groups.
- Since evaluation is carried out in the small groups, attendance and attitude in the large groups drop.

Another source of variability stems from the uneven attitude and profile of faculty members. Some faculty members can be reasonably expected to apply certain participative methodologies in a value-adding manner, while as others, if requested to apply them, may do so in a counterproductive way, leading to the dilemma of whether to allow heterogeneity in methodology.

Course-level design decisions that are being tested and monitored to tackle these challenges include:

- Stand-alone modules that can be taught in the small groups without precedence relationships. Some chunks of the syllabus are not excessively dependent on the rest of the components. They can be used to decouple the schedule of the various small groups; small groups that, due to the reasons mentioned above, find themselves "ahead" of the required theoretical contents simply devote a session or two to these semi-independent modules.

- Grading only some of the assignments. Grading only a fraction of the assignments or intermediate tests each student has submitted reduces grading workload, thus allowing more frequent and/or more complex assignments. A significant drawback is the generally negative attitude that students display towards sampling based grading. Various measures should be proactively taken to minimize this resistance, including clearly explaining upfront the whole grading procedure and its rationale and grading the same assignments for each student.
- Extensive utilization of educational IT tools. It encompasses fully exploiting the administration functionalities of Web based Learning Management Systems (such as Moodle©) to automate assignment collection, identify students that failed to turn in their assignments, etc. It also involves IT mediated grading, particularly through the utilization of test databases.
- Integrating antiplagiarism tools in the Learning Management System: The use of tools such as Turnitin© might help to deter plagiarism. However, using this tools, if not properly integrated with the LMS being used, increases the assignment administration workload. Use of widely utilized LMS's, such as open-source Moodle, increases the chances that antiplagiarism tools have been seamlessly integrated. This first quarter, an integration of Turnitin© into a Moodle-based LMS is being tested, with mixed results so far.
- Reutilization of existing educational material. Approaches such as using OpenCourseware can reduce the effort required by these participative methodologies.
- Integrating research projects into the pedagogic methodology. Actively engaging the students can be facilitated by involving selected students in actual research projects, as well as by including as a specific aim in the research projects the production of results that can enrich the educational process. In this specific case, a multi-year research project in which the whole Engineering Management group is involved provides both the setting for allowing particularly competent and motivated students to get an initial exposure to research, and a wealth of real-life problems, models and situations that are being used to develop the material for the practical sessions, thus leading to substantial synergies.
- Factoring attendance into the continuous evaluation. Initially, attendance was monitored in both the large and the small groups, with the idea of factoring it into the calculation of the continuous evaluation grade. It led, however, to classes in the large group being full of students that were there merely because they were forced to, who did not bother to listen and kept talking to each other, rendering the sessions quite hard to manage. The current approach is to make attendance to the large group sessions voluntary and to control attendance at the small group sessions.

V. CONCLUSIONS

The more tangible and formal EHEA elements, such as adoption of the three cycle structure, ECTS or Diploma supplements can be "imposed by decree" and will eventually be implemented. However, effective adoption of the supporting methodological and cultural elements, such as the shift towards an active learning, student centric, learning outcomes based approach is much less certain. On the other hand, implementing EHEA's formal aspects without adopting its methodological underpinnings could actually make things worse. The approaches and lessons discussed in this paper might be helpful in overcoming the stumbling blocks that hinder that implementation.

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