CDIO@ISEP: "A STAIRWAY TO HEAVEN"
(A CDIO CONTRIBUTION TO EUR-ACE CERTIFICATION)

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ABSTRACT

This paper describes how the adoption and progressive application of the CDIO Initiative™ at the Informatics Engineering bachelor and master programs of ISEP contributed to achieve very good results since 2008. Some of these results are explained in more detail. Current and future initiatives related to Portuguese, European and worldwide program accreditation and certification are described in a second part of the paper. In the conclusions are confirmed the expected benefits of CDIO application in the operation of modern informatics engineering programs, but also the great added value of CDIO for increasing the chances of successful program accreditations and certifications – *a stairway to heaven*…

KEYWORDS

Informatics, engineering, CDIO, accreditation, EUR-ACE, ABET, ISEP.

INTRODUCTION

CDIO is a worldwide known educational framework for improving and sustaining the teaching/learning process of engineering or similar programs. The School of Engineering – Polytechnic of Porto (ISEP) was the first higher education institution in Portugal to embrace the CDIO Initiative™ [1] and apply its standards, practices, recommendations and tools in two informatics engineering programs.

This paper describes how CDIO influenced the accreditation and certification initiatives of ISEP Informatics Engineering bachelor and master programs that emerged after the Bologna curricular reform [2] occurred in 2006-2007. Some CDIO long range benefits for both programs are also described and explained.

The principal objective of this paper is to disseminate our CDIO experiences and to emphasize the very positive results of CDIO application in the operation of informatics engineering programs, highlighting its important contributions for successful accomplishment of accreditation and certification processes.

A secondary objective of this paper is to identify new opportunities for program improvement by reinforcing CDIO application and subsequently achieving other highly recognized accreditations and certifications, and to help in the winding road to a robust quality assurance context.

In this paper the background section describes the contexts of ISEP, Informatics Engineering and CDIO application. The following section addresses the topics of evaluation, accreditation and certification in Europe, also referring some existing qualifications frameworks. After comes a section about our experience with the EUR-ACE certification process. The next section is about the worldwide effort for accreditation of ISEP Informatics Engineering programs, focusing on the ABET accreditation process. Finally we present the conclusions.

BACKGROUND

ISEP is one of the five largest engineering schools in Portugal, with more than 6750 students, 420 teachers and 130 staff. It is located at Porto and in 2011-2012 lectured 11 first cycle and 10 second cycle Bologna engineering programs. ISEP adopted the CDIO Initiative and joined the consortium in 2008. The most important aspects of CDIO application and influence at ISEP since 2007 are:

- Introductory engineering courses in almost all programs;
- Workspaces/laboratories available in all programs;
- Lots of problem/project based curricular work;
- Many extra curricular institutional activities for students;
- Active learning largely dominant in classes;
- Periodic project based teamwork in many programs;
- Capstone “professional” project in most programs;
- Student integration into R&D units of ISEP (both at first and second cycles);
- Pedagogical support group – Focus on pedagogical support to educational activities;
- Technological support group – Promote the use of complementary (technological) educational resources by faculty and motivate/encourage students for alternative and more pro-active learning processes;
- Teacher participation in events for improving pedagogical practice: IEEE Real-World Engineering Projects [3] and others.

Between 2003 and 2006, the Informatics Engineering Department worked on the reformulation of its programs using, as main frameworks, the Association for Computing Machinery (ACM) Computing Curricula [4] and the CDIO Initiative, as well as its previous experience in lecturing professionally oriented informatics courses and programs. For the group in charge of this reformulation, it was consensual that the new “Bologna study plan” should have a large percentage of project work. The Informatics Engineering first cycle (LEI) study plan was essentially inspired by the CDIO Generic Syllabus version 1.0 [5], but for the “Technical Knowledge and Reasoning” part the ACM Computing Curricula recommendations were used – an Overview Report and five Curriculum Reports on Computer Science, Computer Engineering, Information Systems, Information Technology and Software Engineering [4]. The most important contributions came from the “Computer Science Report” (2001 version) and the “Overview Report” (2005 version):

- The ACM “Computer Science” curriculum report provided the scientific skeleton of the new Informatics Engineering study plan, 19 courses in a total of 30, most of them having prerequisites, which imposed limitations to the courses sequence;
- The remaining 11 courses were mainly derived from CDIO recommendations and the ACM “Overview Report”: 3 science-based courses, 2 information systems courses and 6 “design-build-test” courses (one per curricular semester, including the Capstone Project).

Figure 1 shows the LEI current study plan (revised in 2006), in which an ECTU is one unit of curricular credit (ECTS [6]). The first to fifth curricular semesters are based on 12+4 weeks classes, in which the last 4 weeks are fully devoted to problem based group projects. The sixth semester has classes during 5 weeks and the rest is mainly for the Capstone Project. Figure 2 shows the MEI current study plan (approved in 2007), based on “major” area courses complemented by “minor” courses or individually selected elective courses.

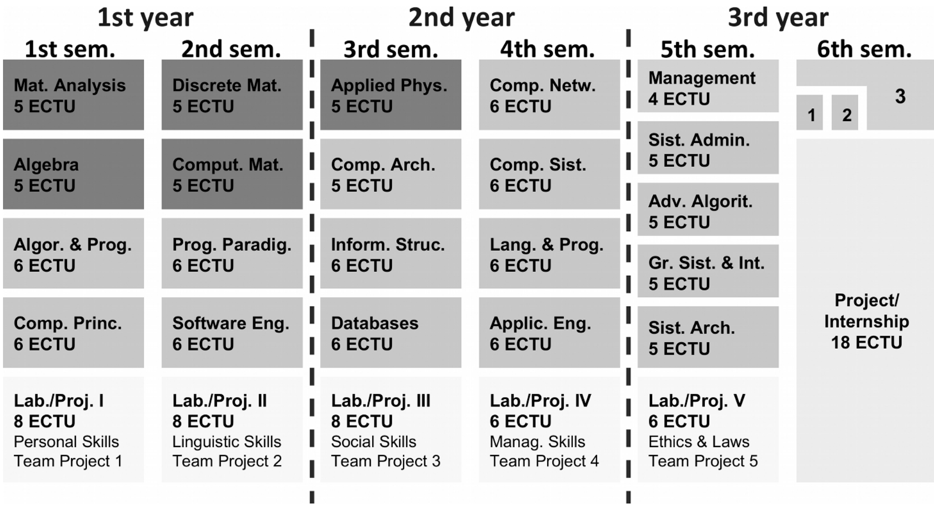

Figure 1. LEI study plan since 2006-2007

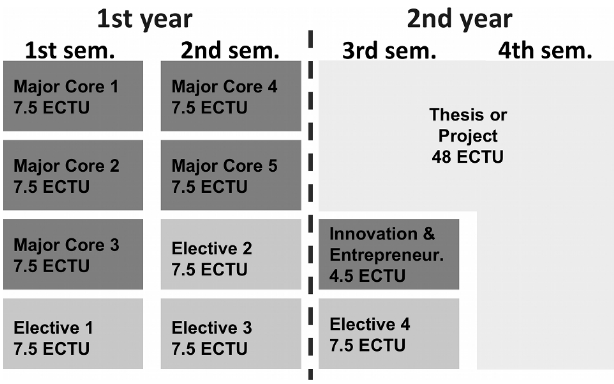

Figure 2. MEI study plan since 2007-2008

CDIO main contributions (standards and good practices) to study plans in Figures 1-2 were:

- An improved hands-on approach to informatics engineering – Standard 1;
- Integration of personal, group, professional and other skills – Standard 3;
- A course to introduce informatics engineering (“Computing Principles”) – Standard 4;
- “Design-build-test” courses (“Lab./Projects” and “Capstone Project”) – Stds. 5 and 7;
- A process for the definition of global program outcomes – Standard 2;
- The balance between “science”, “management” and “engineering” courses.

Figure 3 describes the identified outcomes for the Informatics Engineering bachelor cycle (the “L” cells) and master cycle (the “M” cells), with the second cycle significantly improving and specializing the knowledge, capabilities and competence of LEI graduate students. The Informatics Engineering second cycle (MEI) was designed in parallel with LEI providing four specialization areas. The CDIO Generic Syllabus was the starting point for LEI Syllabus version 1.0, which was approved in May 2008. Work on MEI Syllabus started in 2008 and the current MEI Syllabus was defined in July 2009.

LEI+MEI Syllabus - Main Outcomes	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
1 TECHNICAL KNOWLEDGE AND REASONING	**L**	**L**	**L**	**L**	**M**	
1.1 KNOWLEDGE OF UNDERLYING SCIENCES	L	L	L			
1.2 CORE ENGINEERING FUNDAMENTAL KNOWLEDGE	L	L	L	L	M	
1.3 ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE	L	L	L	L	M	
2 PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	**L**	**L**	**L**	**L**	**M**	
2.1 ENGINEERING REASONING AND PROBLEM SOLVING	L	L	L	L	M	
2.2 EXPERIMENTATION AND KNOWLEDGE DISCOVERY	L	L	L	L	M	
2.3 SYSTEM THINKING	L	L	L	M		
2.4 PERSONAL SKILLS AND ATTITUDES	L	L	L	M		
2.5 PROFESSIONAL SKILLS AND ATTITUDES	L	L	L	L		
3 INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	**L**	**L**	**L**	**M**		
3.1 TEAMWORK	L	L	L	M		
3.2 COMMUNICATIONS	L	L	L	M		
3.3 COMMUNICATIONS IN FOREIGN LANGUAGES	L	L	L	M		
4 CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT	**L**	**L**	**L**	**M**		
4.1 EXTERNAL AND SOCIETAL CONTEXT (*)	L	L	L	M		
4.2 ENTERPRISE AND BUSINESS CONTEXT (*)	L	L	L	M		
4.3 CONCEIVING AND ENGINEERING SYSTEMS	L	L	L	M		
4.4 DESIGNING	L	L	L	M		
4.5 IMPLEMENTING	L	L	L	L	M	
4.6 OPERATING	L	L	L	M		

Figure 3. Minimal expected outcomes for Informatics Engineering 1st and 2nd cycles

In terms of CDIO standards implementation, Figure 4 shows the state of LEI in 2009 and 2012, with a substantial progress achieved since 2009 (a detailed description of LEI creation and evolution is available in [7]).

	CDIO Standards Implementation at ISEP (0-5 scale)	LEI 2009	LEI 2012	LEI+ MEI 2012
1	The Context	3	**5**	**5**
2	Learning Outcomes	2	4	3
3	Integrated Curriculum	3	4	3
4	Introduction to Engineering	3	4	4
5	Design-Implement Experiences	4	**5**	4
6	Engineering Workspace	3	4	4
7	Integrated Learning Experiences	3	4	4
8	Active Learning	2	4	4
9	Enhancement of Faculty Skills Competence	0	2	2
10	Enhancement of Faculty Teaching Competence	1	2	2
11	Learning Assessment	2	4	4
12	Program Evaluation	1	4	3

Figure 4. CDIO Standards Implementation at LEI/MEI in 2009 and 2012

In 2009 the Dean of ISEP defined the EUR-ACE® Quality Seal certification as a relevant goal for all master programs of ISEP, to be desirably attained before the first round of engineering accreditation by the Portuguese agency A3ES-PT [8] between June 2012 and July 2013. Considering the good results in LEI and MEI performances achieved due to CDIO adoption, the MEI program was chosen as the first program for EUR-ACE certification, which in Portugal is managed by OE-PT [9] (Portuguese engineering professional association) as member of the ENAEE association [10].

As a road-map for program accreditations and certifications, Figure 6 shows the current time-line of the LEI+MEI road-map, including the EUR-ACE® Quality Seal attributed to the MEI program (April 2012).

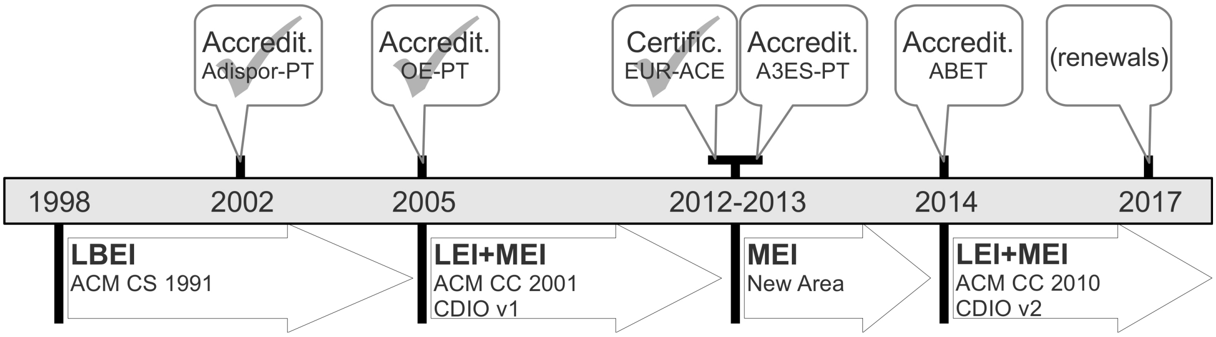

Figure 5. Time-line of accreditations and certifications for LEI+MEI

The “turmoil” due to Bologna Process curricular reform and CDIO adoption/application (2006-2008) in LEI/MEI disappeared by the middle of 2008. Since then four years have passed and most changes in LEI/MEI were mostly process-related and operational. In 2013 LEI and MEI will be subjected to accreditation by A3ES-PT, which will take into account professionally oriented certifications like EUR-ACE.

After LEI/MEI full accreditation by A3ES-PT in 2013, there will be an overhaul of LEI and MEI curricula, driven by most recent ACM Computing Curricula documents and CDIO instruments (Syllabus 2.0, etc), in order to prepare for the submission of a LEI+MEI accreditation request within ABET [11].

EVALUATION, CERTIFICATION AND ACCREDITATION IN EUROPE

In [12] Maury describes how the problem of expressing qualifications shifted, from a general aptitude to take a specific job, to a list of particular aptitudes to tackle certain professional situations. Nowadays, an aptitude is typically called a “competence” and, together with “knowledge” and “skill”, they are the components of an itemized list known as “learning outcomes”. Since 2000 the use of a “structured list of expected outcomes” (i.e., a qualification framework) is globally widespread and many variations appeared. In the engineering domain this phenomenon has been quite dynamic and several qualification patterns emerged, but many objections referred by Maury for “lists of outcomes” still apply: duality between outcomes and course programs; outcomes assessment; education is more than just outcomes; outcomes are too immediate; outcomes may be too general. Even so, this analytical approach to qualification has been beneficial to higher education and facilitates the evaluation and accreditation/certification procedures.

Program evaluation is one of the CDIO Standards with a large potential impact in certification and accreditation program activities. To simplify self-evaluation and provide readability and comparability, Gray *et al*. [13] proposed an updated version of CDIO Standards evaluation with customized rubrics and examples of evidence of compliance. The evaluation data in Figure 4 was produced using those rubrics, contributing to support the plan-do-check-act approach of CDIO.

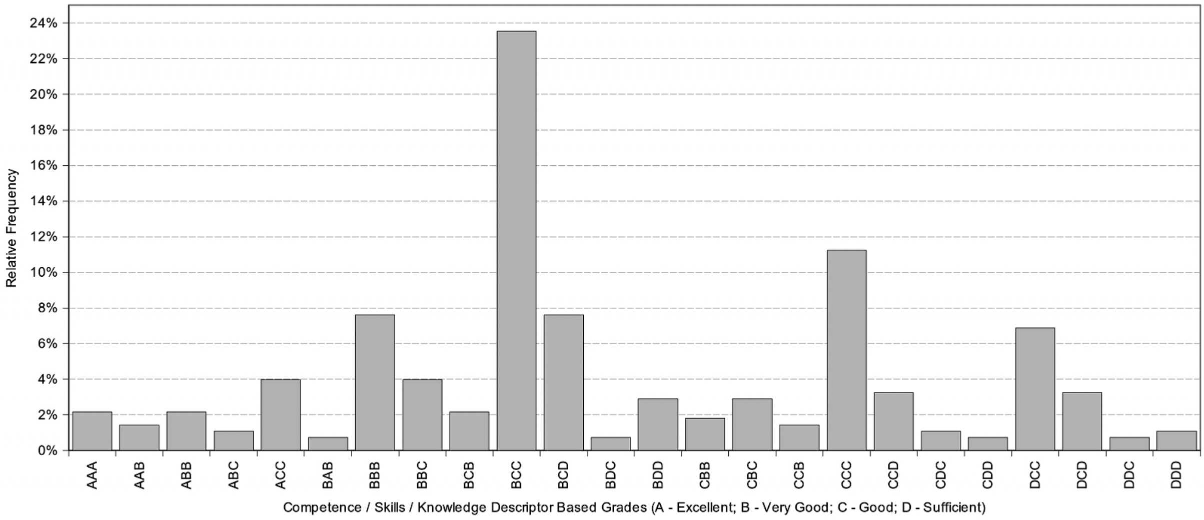

Figure 6. Competence/Skills/Knowledge Grading for LEI graduates 2008-2011

Figure 6 is another example of a high level tool to evaluate the process component of engineering education in LEI, aiming to identify undergraduate stereotypes in terms of competence, skills and knowledge [14]. Apart from being useful for program self-evaluation, this tool also acts as a framework for employers to qualitatively describe what kind of professionals they are looking for. This is achieved by means of a three letter code (A-excellent, B-very good, C-good, D-sufficient) representing the desired engineering competence, personal/non-personal skills and scientific/technical knowledge of candidates: from Figure 6 almost 24% of LEI undergraduates are *very good in competence*, *good in skills* and *good in knowledge* (BCC), and 10% of undergraduates are *excellent in competence* (A??).

In our opinion self-evaluation and evaluation in general is necessary but not sufficient for sustaining a good engineering program. In [15] we describe how CDIO was chosen as the foundation for accreditation and certification activities at ISEP, starting with the LEI+MEI programs. Being an engineering educational framework in "production" since 2002, CDIO is not the only engineering framework available (for example, "The 5 E'S" from Group T [16]).

In [17] Azevedo identified three major levels of frameworks:

- High level frameworks, of general nature, describing global qualifications associated to degrees – examples: Bologna Process, EQF [18] and A3ES-PT;
- Sectoral frameworks, centered on scientific and technological areas, directly related to professions – examples: EUR-ACE, ABET and CDIO;
- Contents descriptors, characterizing main or core curricula contents and methods – example: ACM Computing Curricula for computer science based programs.

Also in [17] the author compares in detail several frameworks and states that EUR-ACE is more useful than high level frameworks like Bologna or EQF and comparable to ABET and CDIO. Nevertheless, in [19] Malmqvist presents a very objective and detailed comparison of the CDIO and EUR-ACE frameworks, concluding that CDIO is more encompassing, educationally extensive and useful for running a continuous improvement process.

Since 2007 the EUR-ACE® Quality Seal, supervised by ENAEE, is managed by 7 national agencies which award the certification to higher education engineering programs satisfying an extensive set of quality requisites. To apply to the EUR-ACE® Quality Seal, a program has to deliver a template-based program self-evaluation, followed by external evaluation by an experts committee (two day visit). Subsequently a final evaluation report is produced by the experts committee and a final decision is made by the corresponding national agency.

In 2010 Castelli *et al*. [20] proposed a new engineering framework for integrating the general descriptors of EQF and the structure/contents of the CDIO Syllabus, aiming to increase transparency in the definition and management of learning outcomes, as well as providing a reference system to create more readable engineering qualifications across Europe. Despite its potential, this EQF-CDIO integrated framework is not ready for large scale program accreditation or certification.

Another well-know engineering framework used for program accreditation/certification is ABET, which addresses program learning outcomes and its assessment, but also other issues not covered by CDIO. In [21] Crawley *et al*. compared the CDIO Syllabus and the ABET EC2010 Criterion 3 (Program Outcomes and Assessment), concluding that "*in general, the CDIO Syllabus reflects a more encompassing view of engineering than does ABET EC2010, by considering the full product/system/process life-cycle, including the implementing and operating life phases, whereas the ABET EC2010 criteria focus on the design phase. Overall, the CDIO Syllabus includes all of the ABET EC2010 criteria, but the reverse is not the case*". Also in [21] the authors describe and explain how some modifications made to the CDIO Syllabus V2.0 were motivated by comparison with other engineering frameworks like EUR-ACE, Swedish Ordinance, Canadian Engineering Accreditation Board and UK Standard for Professional Engineering Competence, as well as UNESCO "Four Pillars of Education" [22].

A recent study from Augusti and Azevedo [23] analyses developments on engineering qualification frameworks and concludes that only field-specific frameworks "*can give concrete application and put on solid and practical grounds the Bologna* {Process} *objectives*" in Europe.

In 2010, a global initiative "Assessment of Higher Education Learning Outcomes Feasibility Study" (AHELO) was promoted by OECD [24], aiming to "*assess whether it is possible to measure and compare at the international level what undergraduate degree students know and can do on graduation, in order to provide better information to higher education institutions, governments and other stakeholders, including students and employers*". Unfortunately the project is still stuck in its first phase, which focused on "*devising assessment frameworks and instruments that have sufficient validity in various national, linguistic, cultural and institutional contexts*".

Despite all the relevant ongoing activities about qualification frameworks and program accreditation/certification, the importance of quality assurance has been increasing since 2005 and more often qualification frameworks and quality assurance are addressed as a whole. ABET was one of the first accreditation agencies connecting both subjects, but recently many other agencies and organizations have been following that path. One example is the A3ES-PT national accreditation agency, which launched in 2011 an initiative for voluntary auditing of internal systems of quality assurance in Portuguese higher education institutions [25]. This quality assurance emphasized approach to accreditation will be generalized after 2013, and for the Portuguese polytechnics A3ES-PT states: "*In the case of polytechnic institutes, provided they have an internal quality assurance system duly certified by the Agency and in those areas with at least 60% of its academic staff being specialists and/or holding a PhD, there will be a simplified accreditation system for 1st and 2nd study cycles*".

THE EUR-ACE EXPERIENCE

The EUR-ACE certification process is quite straightforward and uses the standard approach in higher education program accreditation/certification:

- A team produces the program dossier using a predefined template provided by the accreditation/certification body.
- The dossier is submitted to the accreditation/certification body.
- An audit team visits the institution to gather evidence about the program and resources, as well as to interview the most important stakeholders: institution and program management, teaching staff, students, alumni and employers.
- The audit team produces a report, which is first sent to the institution for comments, and then is submitted to the qualification committee of the accreditation/certification body. This is the entity with the ultimate responsibility do decide on the program accreditation/certification.

MEI EUR-ACE certification involved the submission of a joint LEI+MEI certification dossier. The ISEP team responsible for this process included the two programs managers, their teams (five faculty members) and ISEP accreditation/certification coordinator.

EUR-ACE Guidelines	**CDIO Standards**	**CDIO Coverage**
1. Needs, Objectives and Outcomes	**1**, **2**, 4	Total
2. Educational Process	**3**, **5**, **7**, 8, **11**	Total
3. Resources and Partnerships	6, **9**, 10	Partial
4. Assessment of Educational Process	12	Total
5. Management System	12	Partial

Figure 7. EUR-ACE Guidelines coverage by CDIO Standards

Figure 7 shows, in our opinion, how CDIO Standards cover the EUR-ACE Guidelines.

The experience with CDIO implementation was very important. In 2010 ISEP revised the course curricular forms in order to meet CDIO requirements (e.g. outcomes quantified using Bloom taxonomy), with the two programs already having stable syllabuses. When the decision was taken to go ahead with EUR-ACE certification, the new requirements were analysed and changes were made in ISEP information system, documents and processes, in order to simplify the administrative component of the EUR-ACE dossier. The course forms were easily adapted to a EUR-ACE compatible format, the only problem being the use of a completely different taxonomy for outcomes description. In the end, both taxonomies were supported, as ISEP decided that the CDIO Syllabus and the Bloom taxonomy were too useful to be discarded, especially because faculty was already proficient in its use.

The learning process is another important section of the EUR-ACE certification dossier. The two programs have different approaches to learning process definition and management. LEI is strictly organized in three simultaneous learning processes, without elective courses. The processes were defined according to the key competence areas described in the LEI Syllabus and validated by the stakeholders:

- Software and system engineering (Figure 8a)
- Programming and modelling (Figure 8b)
- Network and computer systems (Figure 8c)

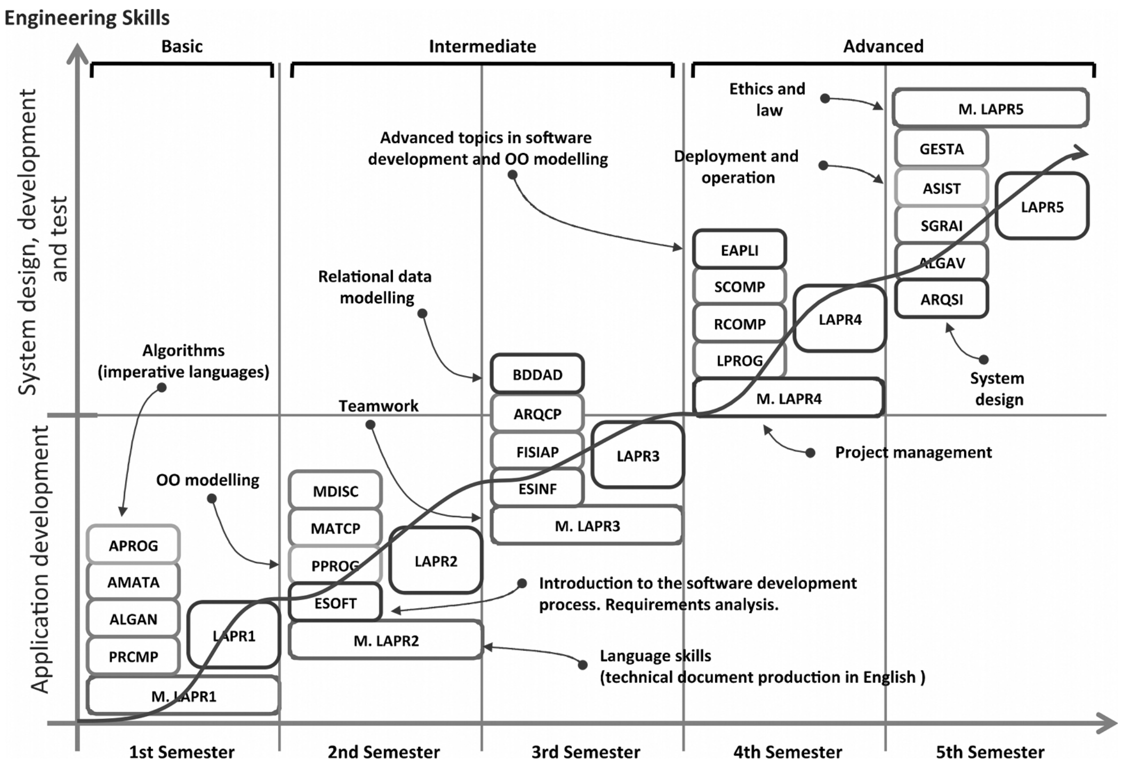

Figure 8a. LEI software and system engineering learning process

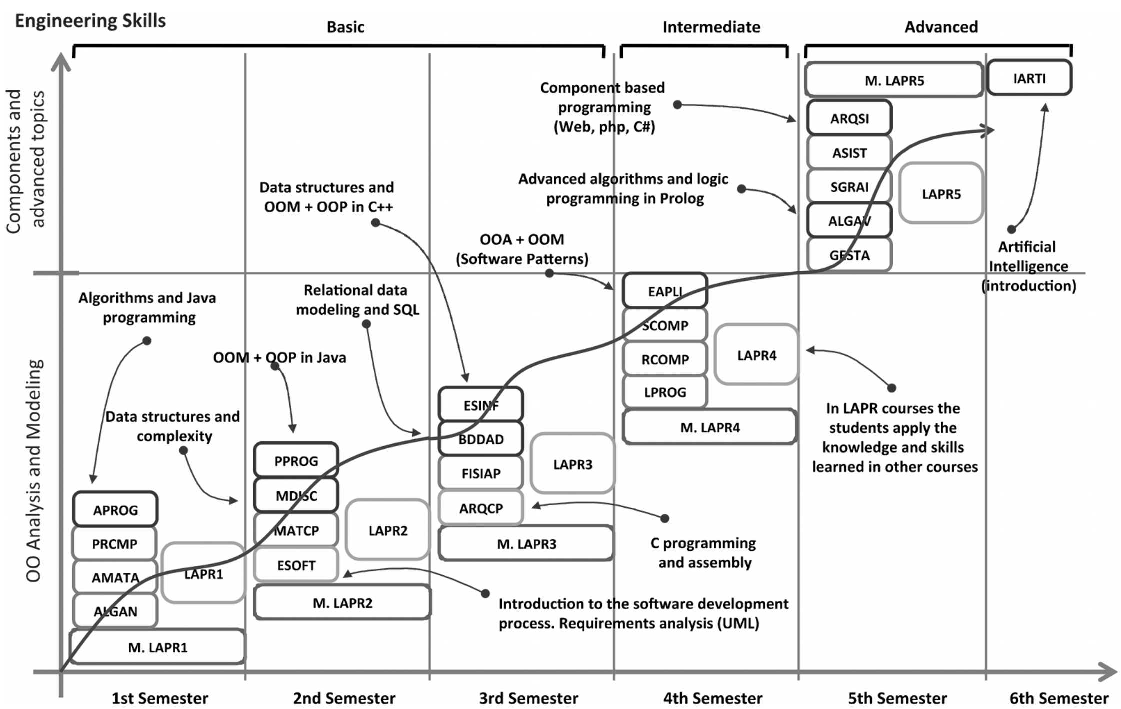

Figure 8b. LEI programming and modelling learning process

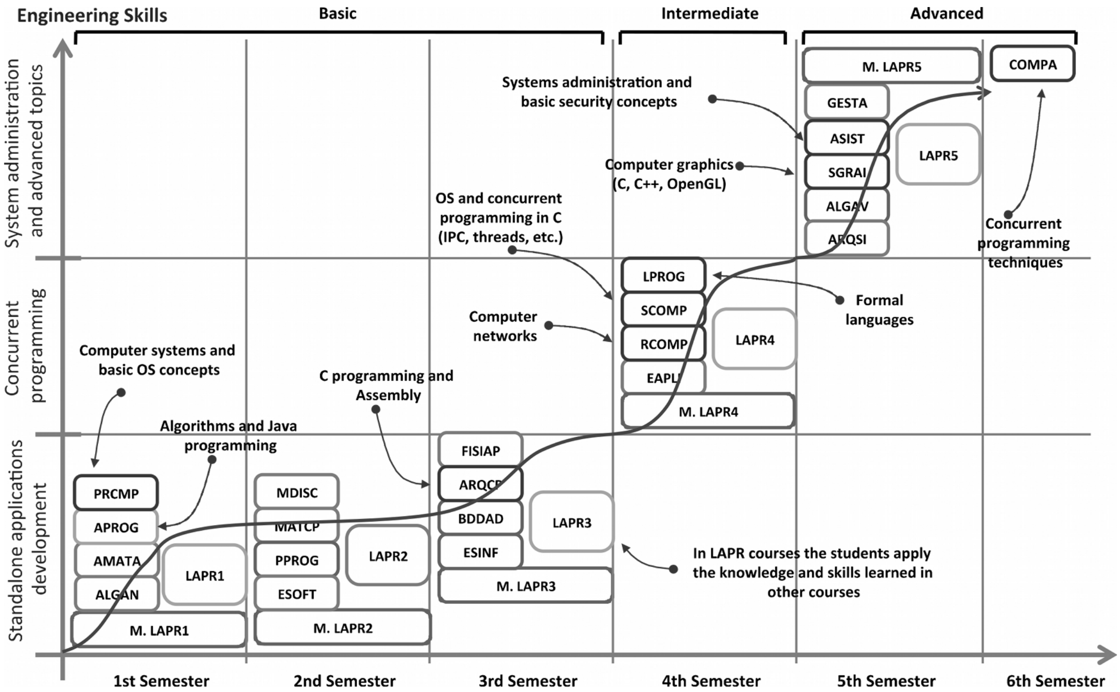

Figure 8c. LEI network and computer systems learning process

Also related to the learning processes, compliance with CDIO Standards 6, 7 and 8 was important to fulfil EUR-ACE requirements. The five integrated learning experiences courses (*Lab./Proj. I-V* in Figure 1) are, almost by itself, a great evidence of a robust learning process. LEI and MEI combined have six integrated learning experiences courses, as well as the LEI Capstone Project and the MEI Thesis/Project courses. In 2010 a CDIO based management framework was developed [26] in order to support the efficient management of LEI, a program with more than 1200 students.

MEI, on the contrary, was structured as a major + minor program with elective courses. No unified approach could be developed for such different realities, thus the two programs were presented as complementary, rather than an integrated five year (300 ECTU) program, which is the most common approach for engineering programs in Portuguese universities. EUR-ACE auditors agreed with our approach, though they recommended some improvements in the master program structure, namely a more strict control in the selection of elective courses.

Regarding the final quality control of LEI graduates, the performance of students on the Capstone Project course was regarded as a main component for the quality of graduates. Most of LEI students do a 4-5 month internship in industry or in a R&D institution, and the organisation feedback is recorded by means of a questionnaire addressing technical, personal and social skills. These results are an important input for the program management framework. The predominant scientific nature of MEI Thesis hinders its use as a broad quality control parameter.

An issue that must be improved is the feedback regarding long-term performance of graduates in the labour market. Some data has been gathered using online questionnaires, but the number of replies is still low.

One area of EUR-ACE that CDIO does not explicitly cover is the quality assurance system. CDIO Standard 12 clearly helps and it was the inspiration for the development of a management framework, but it does not provide clear indications on the structure and nature of the quality management system. ISEP is ISO 9001 certified, but the educational processes are not included in the scope of that certification. Nevertheless, ISO 9001 principles and A3ES-PT guidelines for quality management are already used in the periodic assessment of the programs.

WORLDWIDE ACCREDITATION

In the time-line of Figure 5 we envisage a submission for ABET accreditation of both LEI and MEI during 2014, motivated by the need to diversify the future placement of LEI+MEI graduates beyond Europe and Portuguese speaking countries, defining Canada and USA as main alternative targets [27]. Just in USA, for someone with an "informatics" bachelor degree, it is estimated that occupations like Computer Systems Analysts, Applications Software Developers, Information Security Analysts, Web Developers, Computer Network Architects, Network/Computer Systems Administrators, Database Administrators and Systems Software Developers will have a larger than 20% growth rate and a very high number of new jobs until 2020.

Figure 8 describes how the CDIO Standards cover the ABET General Criteria for bachelor program accreditation. In comparison with Figure 7, which relates CDIO Standards and EUR-ACE Guidelines, ABET contains a criterion (Institutional Support) not addressed by the current version of CDIO Standards. This criterion defines minimum requisites for institutional support/leadership and resources for institutional services, financial support and staff management. However, it should be noted that the CDIO Initiative deliberately focuses on engineering programs and does not address institutional issues.

ABET General Criteria	**CDIO Standards**	**CDIO Coverage**
1. Students	**11**	Partial
2. Program Educational Objectives	**1**	Total
3. Student Outcomes	**2**, **5**	Total
4. Continuous Improvement	12	Total
5. Curriculum	**3**, 4, **7**	Total
6. Faculty	8, **9**, 10	Total
7. Facilities	6	Partial
8. Institutional Support	---	None

Figure 8. ABET General Criteria coverage by CDIO Standards

Other that ABET Criterion 8 (Institutional Support), Criterion 1 (Students) and Criterion 7 (Facilities) also contain requisites that are more institutional than program related:

- Criterion 1: policies for student ingress and transfer, academic credit for courses taken at other institutions, academic credit for work in lieu of courses taken at the institution; procedures to ensure and document that graduates meet all graduation requirements.
- Criterion 7: adequate library services and computing/information infrastructure to support the scholarly and professional activities of students and faculty.

Although CDIO does not explicitly address the aforementioned requisites, ISEP institutional practices are in conformance with those requisites, so they are not a real problem. In terms of improving LEI and MEI programs and simultaneously preparing for ABET accreditation, the following initiatives have been identified:

LEI Graduate Grading System (1)

In [14] a graduate grading system (Figure 6) was introduced to serve two essential purposes: describe in a readable and comparable way all LEI graduates in terms of Knowledge, Skills and Competence (as defined by EQF); and to simplify and improve the interaction between employers looking for informatics engineers, LEI graduates and ISEP. The proposed system uses three dimensions and a five point qualitative scale (letters A, B, C or D) to grade any LEI graduate by means of the three letters and a wildcard symbol.

In the near future we intend to automate the calculation of the grades within ISEP information system and generalize the use of grades by graduates and employers.

LEI Curriculum as a Set of Simultaneous Learning Processes (2)

Three simultaneous learning processes have been identified in LEI: Networks and Computing Systems; Programming and Modelling; and Software and System Engineering (Figures 8a-c). Each learning process uses an iterative approach, in which the student continuously refines skills over several courses and develops increasingly complex projects. As each learning process covers five semesters, three proficiency levels were defined: basic; intermediate; and advanced. A detailed description of objectives was defined for each level, as well as the contributions of each course to each process critical path. In the sixth curricular semester the three learning processes converge into a capstone project – in the second semester of 2011-2012, 332 capstone projects were validated for 180 students, with 94 placed in industry sponsored internships outside ISEP and 40 in R&D internships; the remaining 46 students opted for personal or teamwork projects within ISEP.

Although this process based approach to learning has proven useful, it is amenable to improvements in order to increase the learning efficiency.

MEI Curriculum as a Set of Parallel Majors (3)

MEI curriculum is based on three “majors”, each one with five core courses, two common courses and a set of four elective courses. These elective courses may be used as a “minor” or chosen at student discretion from a menu. In each major such freedom introduces a large variability in the corresponding master graduates, which creates problems like complexity in the MEI Syllabus, variations in the final learning outcomes, complex course management, etc.

As this subject was a matter of debate during the EUR-ACE committee visit, MEI may be modified in order to reduce the “random” selection of elective courses and stimulate the students to choose one of several predefined templates, more adapted to the labour market. One new major in MEI is expected to start in 2012-2013.

MEI Thesis/Project Course (4)

The MEI Thesis/Project course was designed to be the main design-build experience for the master study cycle, in the form a scientific thesis developed within an established R&D unit or a technical project developed within a supporting organization. Up to now, most of the master graduates have chosen thesis instead of project and many students take too long to finish their project. Most MEI students work during daytime and attend classes at night.

The solution to this problem can be provided in part by the MEI personas initiative (***6***), but also by promoting “master projects” within organizations and favouring teamwork projects instead of individual only projects.

LEI and MEI Syllabuses (5)

Both LEI and MEI Syllabuses were created using the CDIO Generic Syllabus version 1, but version 2 includes many relevant changes and additions that reinforce its importance as a program descriptor tool. The new sections about Leadership and Entrepreneurship, missing in the current MEI Syllabus, will improve its relevance as an educational document.

MEI Personas (6)

In [28] Ystrom *et al*. presented a "persona" methodology to describe the future professional roles of engineering graduates, whose results were then used to define the required knowledge, skills and attributes to deliver along the study plan. The authors also have shown many evidences of the benefits of identifying and creating engineering personas.

Inspired by the work of Ystrom *et al*., LEI and MEI program directors have already started a "persona" initiative at ISEP. In the case of Informatics, we anticipate that it will be possible to initially define a set of "informatics personas" and, in a second phase, the set of "MEI personas", in close interaction with program stakeholders.

LEI Stereotypes versus MEI Personas (7)

This initiative can only be started as soon as MEI personas are defined. We will analyse if there is any meaningful relationship between LEI stereotypes (derived from the LEI grading system) and MEI personas.

MEI Internationalization (8)

The Bologna Process opened new opportunities for the internationalization of European higher education. In many countries (Netherlands, Denmark, Sweden, etc) the new master programs started being successfully taught in foreign languages (mostly English) and, in a smaller scale, the same happened to bachelor programs.

With the declining birth rates in Southern Europe, and especially in Portugal, it becomes more and more important to internationalize the MEI program, so that other European students are attracted to Portugal and to ISEP. As such, in the near future MEI will have to be taught in Portuguese and in English. In a longer time span, we also consider the possibility of lecturing LEI in English.

CONCLUSION

The Present

CDIO adoption and application at ISEP Informatics Engineering programs has been very successful, as well as instrumental to improve the process and product components of engineering education at ISEP. Our success in terms of "product" is confirmed by feedback from graduates and employers, but to confirm success in terms of "process" we think feedback from faculty is not sufficient. In our opinion, program accreditation/certification initiatives can also be used to verify the effectiveness of the process component in engineering programs. This was confirmed in April 2012 when OE-PT attributed the EUR-ACE® Quality Seal to the ensemble of ISEP Informatics Engineering bachelor and master cycles – in the domain of Informatics Engineering for the first time in Portugal.

One important conclusion we take is that CDIO implementation is a relevant success factor to achieve EUR-ACE accreditation/certification by the ENAEE association.

We also conclude that CDIO implementation gives a big push to the adoption of a quality assurance stance. In our Informatics Engineering programs it had a positive impact in terms of conformity (*are we doing what we proposed to do?*) and efficiency (*are we doing it correctly without wasting too many resources?*).

The quality of ISEP Informatics Engineering programs is confirmed by good results like:

- First option student applications have increased in the last years.
- Student dropout in both programs has reduced in the last years.
- The completion rate of both programs has increased (more in LEI than MEI).
- More industry contacts with program directors for recruiting students and graduates.
- Industry shows interest in cooperation with the programs.
- Recognition from accreditation/certification agencies, IT academies, industry, alumni.
- Teachers embracing active pedagogical methods in classes.
- The high quality of many LEI capstone project solutions developed by students.
- The high quality of many MEI thesis/project solutions developed by students.

The above list of good results and the need to address new labour markets were an important motivation to pursue other ambitious accreditation objectives, namely ABET accreditation. Nowadays in Portugal (and Europe in general) the need for “total transparency” is increasing in the public funded higher education sector and accreditation/certification of programs by international agencies is an important move in that direction.

The Future

It is expected that Portuguese public funded higher education institutions make the transition to quality assurance operating environments before 2015, as proposed by the A3ES-PT accreditation agency. If not adequately prepared, this transition may generate significant disturbance, with many educational and organizational implications.

As before, we intend to take lessons from CDIO and improve its application during the transition to a quality assurance based future...

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