RESISTANCE TO CHANGE IN INSTITUTIONALIZING THE CDIO STANDARDS: FROM A CASCADE TO AN AGILE IMPROVEMENT MODEL

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ABSTRACT

Educational program transformation plays a recurrent and key role in the future of an institution. An educational reform is a tricky strategic and engineering issue. It is also a complex management challenge which has to overcome possible conflicting and restraining forces. In order to be continuously prepared for national or international formal accreditations, and more easily face resistance to the changes induced by educational reforms, Telecom Bretagne, a French graduate engineering school, has deliberatively chosen to use the CDIO standards as a dynamic tool first under a cascade incremental cycle. Since 2008, our policy of taking standards one step at a time, based on a process model at a slow pace, allows to support peace among educational managers, program developers and teaching staff, so that our approach results in an effective adoption of the CDIO principles. We are now able to share our experience of using some of the CDIO standards to improve program quality and meet accreditation expectations, where industrial partners and students are strong change agents. Our approach instanced in two different programs at Master levels, a medium size full-time generalist program (650 students) and a small size specialized apprenticeship program (120 students), is described and analyzed in this paper. For institutions expecting or encountering some difficulties with staff resistance to changes, our results and the lessons learned will give advice to foster durably the adoption of the CDIO standards and to be prepared for a deeper continuous improvement based on a more agile iterative cycle in order to align more regularly with accreditation requirements.

KEYWORDS

Implementation of the CDIO approach, program evaluation, accreditation, educational change, sustaining curriculum reform, industry and student involvement in the development of engineering education.

INTRODUCTION

Evaluations have a determining effect on the institutional policies and continuous improvement of higher education institutions (e.g., evaluation of science policy of universities, evaluation and ranking of research teams, evaluation of diplomas or education). Nowadays, higher educational institutions are more and more requested to meet quality standards [1]. For this reason, an increasing number of institutions have to implement curriculum reforms [2] and to juggle with a plethora of recommendations and rule books defined by national or international accreditation bodies. Thus, from an educational standpoint, program monitoring and transformation play a recurrent and key role in the future of an institution. An educational reform is a tricky strategic and engineering issue. But, as the leadership is rather light in some institutions, it is also a complex management challenge which has to overcome possible conflicting and restraining forces. Some stakeholders have difficulties in accepting pedagogical and organizational modifications, sometimes not aligned with their viewpoints, regular activities or career expectations.

In order to more easily face resistance to the changes induced by educational reforms and anticipate the future national or international accreditations, Telecom Bretagne higher engineering school has deliberatively chosen to use the CDIO standards [3] as a dynamic tool for continuous improvement since 2008. First under a cascade process model, at a slow pace in order to take into account Telecom Bretagne's own traditions and even inertia, our strategy of taking each CDIO standards one step at a time allowed and still allows to maintain peace among educational managers, program developers and teaching staff. Our approach resulted in a deeper adoption of the CDIO standards and has been instanced in two different programs at Master levels: (i) a medium size full-time generalist program (650 students) with a wide spectrum of knowledge, skills, and competences, and (ii) a small size specialized apprenticeship program (120 students). For both programs, the CDIO standard #1 (CDIO as a context) has first been elected by the board of directors as the main driver of our educational strategy. Nevertheless, at the beginning, key CDIO information and standards were not communicated to most of the teaching staff considering the large scope and alarming complexity of the former. In a second phase, the CDIO syllabus standard #2 has been gently and progressively disclosed to key program designers and ultimately teaching members. Two approaches were then undertaken to formalize the institution syllabus and confirm its alignment [4] with the course curricula, depending on the size of the program: (i) a bottom-up approach for the medium size program and (ii) a top-down approach for the smaller program following a deeper reform of course contents and methods. From that point, standards #3, 4, 5, 7 and 8 relating to educational contents and pedagogical methods were investigated after program self-evaluation (i.e. standard #12) in order to verify the programs effectiveness and efficiency in reaching the intended syllabus outcomes. Today, the focus is on standards #6, 9 and 10 (i.e. workspaces and faculty skills), before further exploring standard #11 (i.e. skills assessment [5]).

Based on the CDIO good practices and recommendations, Telecom Bretagne is now prepared for a deeper continuous improvement based on a more agile iterative cycle, managing several standards at a time. To minimize resistance to change from faculty, industrial partners and students were brought in the process] as strong change agents in connection with the introduction of many standards. The results and lessons learned from our approach in the two programs, with two successive process models, will potentially give other institutions expecting or encountering some difficulties with the engagement and acceptance of their respective stakeholders, some advice on how to foster durably the adoption of CDIO standards in their context.

This paper is structured as follows: the next section proposes an overview of the French higher educational system and the specificities of the French historical elitist *Grandes Ecoles* together with respective accreditation issues. Then, the introduction of project-based learning at Telecom Bretagne is briefly overviewed before presenting the competency approach introduced in the former curricular reform (2003) aiming at defining, as a first phase, an integrated curriculum aligned with the European recommendations on competencies. Then, a second phase based on the CDIO syllabus standard #2 used either in a bottom-up or top-down approach is discussed, before presenting the ongoing third phase addressing other CDIO standards. A following section proposes a conceptualized process model on the improvement cycle finally used, before suggesting future directions and concluding.

FRENCH *GRANDES ECOLES*, NATIONAL ACCREDITATION BODIES, AND QUALITY ASSURANCE

In France, top Engineering Schools and Management Schools are part of the *Grande Ecole* system [6] and graduate at Master level. Historically, this system, with its preparatory schools and associated selective national *concours*, has its sources in the French Ecole Polytechnique (created in 1794). Close to the labor market, Engineering *Grandes Ecoles*, often under the aegis of Ministry of Industry, are the principal medium to create a tank of future high skilled managers [7] for large industries, in France and abroad. There is a fierce competition among the various nationally accredited engineering schools, mostly to attract the best students of the *concours* characterized by strong analytical skill requirements. Some French Universities also propose engineering degrees, which are not recruiting their freshmen via the national *concours,* but at K12 level (e.g. 17 years old).

To support *Grandes Ecoles* engineering schools, on the one hand, the French *Conference des Grandes Ecoles* (CGE) has been created in 1973 as an association including now 216 schools (management and engineering). Its aims are to develop internal information, mutual assistance and solidarity among members; promote the schools, both at national and international levels; perform actions of common interest with public authorities. On the other hand, the CEFI is a joint initiative (1976) of the French Ministry of Industry and Ministry of Higher Education aiming at creating a study and prospective group on engineer educational programs and careers.

Accreditation of Engineering Institutions in France: Landscape

Accreditation bodies propose specific evaluation procedures and criteria worldwide. In France, for engineering schools:

- Every six years higher engineering institutions do their best to align with the CTI criteria. CTI (*Commission des Titres d'Ingénieur*) is the legal independent national accreditation body (existing since 1934, one of the worldwide oldest with ABET) which promotes and controls the engineer title and profession in France. The self-evaluation report to prepare and submit, together with quantified data, is recognized as a complex task which is most often supervised by the dean of academic affairs. The time-period between two evaluations tends to limit the continuity of the self-evaluation process in the absence of a dedicated person responsible for this task within an institution over the years;
- At the European level, managed by ENAEE, the EUR-ACE quality label [8] for engineering degree programs at Bachelor and Master levels is also to be addressed. However, EUR-ACE delegates its label to CTI since 2007;
- More recently, a new independent administrative authority has been created in 2007 for purposes of evaluating French research laboratories. This authority (AERES) has recently defined some criteria to accredit also Universities and high education institutions (e.g. research Masters).

Through the definition, analysis and optimization of their processes, engineering educational institutions are nowadays more and more requested, by professional societies or governmental regulations, to meet quality standards [1]. However, faculty or associations of institutions did not wait for this to enhance the quality of their programs or innovate. The management style of higher education has been discussed for several years, and is still controversial. It is often said that in order to manage a transformation project and to continuously meet quality requirements, two distinct disciplines are to be mastered: engineering (e.g., design, conceive, implement) and management (e.g., plan, decide, communicate, control). For more than ten years now, educational frameworks like the CDIO standards or other requirements (even rules) defined by accreditation bodies (e.g. ABET, EQF/EUR-ACE, Engineers Australia) tend also to integrate processes for better quality management in their standards,

External versus Internal Evaluations

Several models of quality management in education have appeared based on corporate styles as found in the industry, but they are rather hard to enforce in public traditional schools, as it is the case in France. For example:

- The Malcom Baldrige Performance Excellence Program, managed by NIST, proposes education criteria for performance excellence [9]. Customer (e.g. students, stakeholders) and workforce focus are addressed in categories of the corresponding quality framework pursuant to a system perspective. Other categories are leadership, strategic planning, knowledge management, operation focus and results;
- As another example, the European Foundation for Quality management (EFQM) Excellence Model [10] follows a business model. Several concepts underpin EFQM, i.e. result orientation, customer focus, leadership, management by processes and facts, people and partnership development, continuous learning, and corporate social responsibility. This model also focuses on what an organization could do to produce a better service or product for its customers, or service users, as well as stakeholders. The model is based on five key enablers of improvement: leadership, people, policy and strategy, partnership and resources, and processes.

Much more flexible, the CDIO framework, as a well established and accurate recommended practice for curriculum creation, proposes many hints to reform an established engineering program (cf. rationales for each standards and maturity levels in the self-evaluation process). In the CDIO framework [3], there are twelve standards. For each one, one rubric is used for program evaluation (with a hierarchical scoring, scale from 0 to 5) to check conformity with the CDIO principles. The Standard #12, on program evaluation, is CDIO's cornerstone for continuous improvement.

Several evaluation models could cohabit with the ones of incontrovertible accreditation bodies (external evaluation with a clear focus on accountability - moving slightly toward continuous improvement recently), and the CDIO self-assessment method of compliance (internal evaluation deliberatively focused on continuous improvement) is, in our opinion, a complement to them. For a conceptualized model, the interested reader will find examples of internal/external vs. accountability/QA in [1]. As an example, for systematic and continuous improvement at CDIO-scores 4th and 5th levels, well managed processes are a key element. At the maximum level 5, standards 2, 3, and 11 include evaluation by external groups (e.g. alumni, industrial partners), rather than accreditation bodies. But improving programs or innovating in engineering institutions in order to meet social and industrial expectations can be less formalized, and Telecom Bretagne, thanks to various curriculum reforms, has managed several improvements several years ago.

TELECOM BRETAGNE AND PROJECT-BASED LEARNING

Overview

Founded in 1977 under the ministry of Posts and Telecommunications, Telecom Bretagne is a French public research institute and graduate engineering school proposing degrees in ICT through two programs at master level: (i) a medium size full-time generalist program (approx. 200 graduates per year), and (ii) a small size specialized apprenticeship program (approx. 40 students per year). These degrees comply with the European and national higher education accreditation systems. Telecom Bretagne is accredited by CTI since its first years of creation in the 70's. Telecom Bretagne's next CTI evaluation process will start in 2013 (every six years). As a highly selective *Grande Ecole* [6] with approximately 170 full-time academics, the institution is ranked in the top 15 (out of 260) of the French engineering school arena. It is a member of the recently created Mines-Telecom Institute (2012). With thirteen *Grandes Ecoles* (and ten others associated), *Institut Mines-Telecom* represents now a national cluster of 10.000 engineering students (including 28% of foreign students), 1700 Ph.D students, and a task force of 3600 researchers.

Projects in Programs, as a Starting Point Several Years Ago

In the 1970's at Telecom Bretagne, most student capstone projects were mono-disciplinary. The first attempts of transversal projects go back to 1985 for the senior students (engineering project in groups: a topic proposed by an industrial partner per group). From 1994, alongside the more traditional classes (lectures and practical sessions), there was a gradual development of different project types with specific aims. To a greater or lesser extent, the focus was on team work, interpersonal skills, and project management. In 1998 was introduced the entrepreneurship quarter project (4 to 6 students per group). Nevertheless, the integration of projects all along the curriculum was rather informal.

COMPETENCY-BASED PROGRAMS AT TELECOM BRETAGNE SINCE 2003

Nowadays, higher education institutions increasingly focus on competencies, which impacts educational objectives, and subsequently pedagogical and instructional methods. In 2003, in compliance with European requirements on competencies and the French 2002 law requesting higher institutions to deliver their degree thanks to the recognition of life experience (i.e. non formal and informal learning of vocationals), Telecom Bretagne reformed deeply its classical generalist curriculum with a competency focus. However, managing a curriculum change around competencies does not consist in pouring the same old wine into new bottles [11]. An approach focusing on competencies, personal and professional skills, requires specific pedagogical methods. At that time, a specific group was set up to design and coordinate the set of student projects. This provided us with the opportunity for extensive reflection on Project-BL and active pedagogies.

An Integrated Curriculum with Semester Projects

The result was a new pedagogical framework on the basis of our earlier expertise in Project-based Learning (Project-BL). Four semester projects (approx. 120 hours per student per semester, in teams) were designed and implemented (still in place) within an integrated curriculum [11, 12]:

1. During the first semester, the S1 "Discovery" project is based on active pedagogy. The topic is linked to a complex pluridisciplinary system, including the creation of a technical-economic report;
2. The S2 "Development" project consists in a technical development in the discipline of one of our research laboratories. It is supervised by an "expert" instructor. There is one subject per student group;
3. The S3 "Entrepreneurship" project covers the stages of creativity (finding a new service or product), feasibility (technical and economic analyses) and development (commercial pre-validation of the product). The deliverables correspond to a report for decision makers and some kind of demonstration (film, model, scenario of typical use);
4. The S4 "Engineering" project covers several phases of a project life cycle, from reformulating the client's needs, to supplying the final product and its validation. The subject of each project (different for each student group) is proposed by an external partner (industrialist, association, local community, etc.) and by two faculty members from two different disciplines.

The whole framework is centred on the “V” life cycle model of an industrial project. This allows the students to give a concrete expression to the various stages of the four projects.

The Problem of Defining Internally an Exhaustive Syllabus: Phase 0

From a general standpoint, in order to properly assess the changes required to prepare and initiate a competency-oriented program, it is essential to have a common understanding and language for the issues at stake.For a teacher or professor, the concepts and vocabulary used for competency definition and learning outcomes are uneasy to control since they lie at the intersection of business and education worlds, resulting in confusion between the professional vocabulary and the terminology used in the education sphere. The confusion is even greater for native speakers since translations from English are sometimes approximate. Moreover, concepts relatied to competencies are not uniform among the Anglo-saxon and French educational scientists.
As the spectrum covered by the generalist program is wide, as well as the activities led by young graduates, it was difficult to establish and formalize a competency syllabus. Actually, newly graduated students from the *Grande Ecole* system tend to work under various job titles and different sectors, thus it is far from easy to unite a huge variety of professions. Moreover, many Faculty representatives were not prepared to the competency way of thinking, and some of them tend to desperately rely on core disciplinary knowledge exclusively.

Initially, we attempted to define a complete system of reference (internal syllabus) for competencies (including not only skills, but also knowledge), encompassing all the courses of the curriculum. After several iterations, it appeared that the level of granularity was not shared, the completeness was regularly controversial, some Faculty members tended to defend their learning outcomes, even refined and low-leveled, as core fundamentals to appear as headers, a.s.o. (i.e. group of 8 members during 2 years, approx. one meeting per 2 months, without usable and formal results). We had to endure debates on terminology, non convergence, disagreement, loss of energy, granularity, coherency and alignment of LO with existing program (elective, major, minor).

Hence, we started on projects, without confronting majors and minors (which are more disciplinary). The core knowledge and skills we targeted were mapped with abilities in accordance with Bloom’s taxonomy. However, at the time, this global approach was too exhaustive and complex, and was not accepted by our instructors. Thus, we opted for a lightweight approach as regards competency definition and assessment. We followed a progressive approach in which project designers and associated tutors or supervisors elaborate and use simple core marking grids. Competencies are assessed only if they are clearly defined. Other, less visible or quantifiable, competencies based on attitudes or personal abilities are only recorded so as to facilitate a formative perception by students of their own competency profile and help them with their personal development plan. In practice, this means that we only base our assessment of the ability level reached by our students on deliverables (e.g. written reports or prototypes) and that we restrict our evaluation to professional abilities and skills which are actually observed during the project sessions.

Accordingly, intended learning outcomes were defined per project based on the authentic main competencies which are at stake in some professional environments relating to ICT engineering domains and future careers as senior engineers, including management skills. Without aiming to cover all the possible types of competency, we decided to retain those which were developed in previous projects, and to add others related to inter-disciplinary and to transversal competencies, e.g. written, oral communication and team work. The level for each ability progressed during the S1 to S4 projects.

First Phase 2006: Generalizing Skills and Competencies

Thanks to the lessons learned from the previous introduction of learning outcomes [13], competency oriented, in the project integrated framework, a specific group was created in Spring 2006 to consider this approach in the overall generalist curriculum, including minors, majors, introduction courses for freshmen, etc. However, to ensure convergence, it was decided to align with the learning outcomes required by the French accreditation body (providing criteria like the ABET "A-to-k"). Although rather abstract, it was an entry point to minimize unfruitful debates on terminology, non convergence, disagreement, loss of energy, and finally to align with learning outcomes of existing courses (elective, major, minor).

During that period, the part-time apprenticeship program followed the same process. In both cases, generalist and specialized curricula, no formal quality approaches were in place, even if many hints regularly popped up to verify the quality of the program (i.e. student interviews, boards of industrial partners, etc.).

JOINING THE CDIO INITIATIVE IN 2008

Thanks to a visiting position at MIT, a Telecom Bretagne researcher discovered the CDIO initiative in 2007. In line with our extensive use of project-based learning and our integrated curriculum, it was decided to join the initiative, to gain the benefits of shared good practices of the network with a view to internal continuous improvements, rather than to aim at a quality label. The CDIO standard #1 "CDIO as a context" was thus recognized by the dean of academic affairs, as principles to follow, in a mission statement.

Second Phase 2008: Alignment with the CDIO Standard #2 Syllabus

The mature syllabus standard #2 was viewed as an entry point to leverage our previous problems of defining, by ourselves, the Telecom Bretagne syllabus. The objectives were to gain a better coherency and alignment of learning outcomes with existing courses, as well as less resistance and inertia of stakeholders through the introduction of an external exhaustive syllabus, and to anchor the foundations of our integrated curriculum within the CDIO canvas. Depending on the program, i.e. generalist and specialized, two approaches were investigated:

1. **A bottom-up approach** in the generalist program *Profession-oriented*: each course leader selected some elements of Syllabus #2, within the 71 elements list (level 2). Each leader was requested to:
    a. Clarify intended learning outcomes for the courses he/she managed;
    b. Tag the LO which are linked to one or several CDIO LO(s);
    c. Classify those LO(s) in the Andersen & Krathwohl taxonomy;
    d. Refit program booklet and objectives, potentially taking the list at level 3 to organize finer grained course learning outcomes;
    e. Punctually adjust and adapt the associated course contents.

    From that point, a first quantitative cartography of the Telecom Bretagne profile could be inferred (on the overall curriculum, for majors, minors, etc., cf. Figure 1). The industrial partners could also position their requirements thanks to the CDIO syllabus (i.e. questionnaire sent to more than 200 contacts) for comparison. The level 1 was used for such to minimize complexity (17 elements).

2. **A top-down approach** in the specialized apprenticeship program during the 2009 profound reform *Jobs-oriented*: This part-time program is in strong correlation with industry and close to the market skill needs. Then, for this second case, a list of 3 priority jobs was selected: Telecom, network and software designers and developers, IT project managers. Based on those jobs, and thanks to the CDIO syllabus and

professional competencies defined by professional bodies, proficiency levels were associated with an exhaustive list of selected skills and knowledge. This list was discussed with specific industrial partners who could also add some elements. Then, the program contents were defined, in alignment with the learning outcomes. The implementation process was covered rapidly.

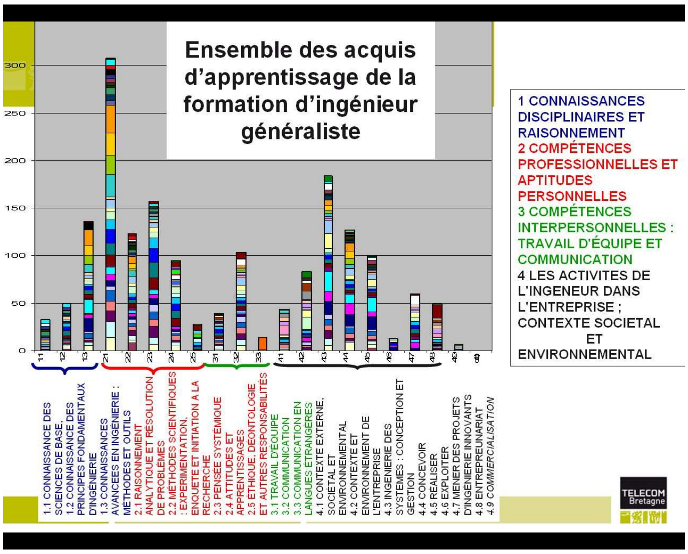

Figure 1: Quantitative CDIO learning outcomes of the generalist curriculum (2010).

CLOSING THE LOOP WITH THE REMAINING STANDARDS: THIRD PHASE

Prior to joining CDIO, semester projects and an integrated curriculum over the three years were already in place, covering with a good maturity level CDIO standards #4 and #8. The CDIO standard #2 was the key entry point to prepare the future alignment [4] of our generalist curriculum based on its existing contents. More classically, CDIO standard #2 permitted us to create the syllabus of our specialized program and then define course contents.

Following constructive alignment principles, an educational program relies on three main pillars: (i) an intended curriculum, (ii) a taught curriculum, and (iii) a validated learned curriculum. As of today:

- Our institution is not far from being prepared to more deeply engage in standard #11 (student assessment) based on those principles;
- But before that, staff skills will have to be enhanced, based on CDIO standard #9 and #10. Even if some of the Faculty members publish or attend conferences in engineering education, or follow some vocational training in pedagogy (e.g. two slots of 3 days offered on a voluntary basis each year at Telecom Bretagne), the number of staff fully engaged do not covers all faculty. Approximately 15% of the teaching staff is confident with the CDIO standards and details. 40% are aware on the broad lines, mainly standard #2. There is a comfort zone of “business as usual in education” so as to keep energy for scientific research, contracts, and quest of excellence for research evaluation of laboratories and individuals. The French higher educational system, like many others worldwide, still relies on the promotion of scientific researchers (based on the “contracts, publish or perish” and “counter of Ph.D students” principles). The recognition of educational involvement starts, to date, to be also taken into account for the promotion of A/Professors to Professor status;

- CDIO standard #6 on workspaces is used as a pump to more deeply claim requirements to financial services to modify existing spaces;
- Finally, the CDIO self-evaluation standard #12 is under preparation, as it will be discussed in the next section.

CONCEPTUALISATION: PROCESS MODELS

Although we encountered some inevitable managerial problems in introducing competency way of thinking and designing programs, our experience in two distinct engineering programs (bottom-up and top-down approaches) shows that the main managerial difficulty is to regularly confront resistance to changes and prevent regression. Several French higher education staff have some subjective reluctance vis-à-vis what is relative to quality assurance. In France, CTI accreditation is a standard of fact “to stay in the match” for *Grande Ecole*. It is largely recognized by several stakeholders, particularly the teaching staff, and as such supports a relative good acceptance. But in our context, we greatly benefited from the introduction, at a slow pace, of some CDIO standards, to better support continuous improvement as an internal tool. Today, our experience using the CDIO standards to meet accreditation expectations is largely beneficial and permits us to get ahead of the competition. The standards are a very good additive to leverage continuous improvements in a prospective manner. We are now beginning to harvest the benefits of the efforts expended.

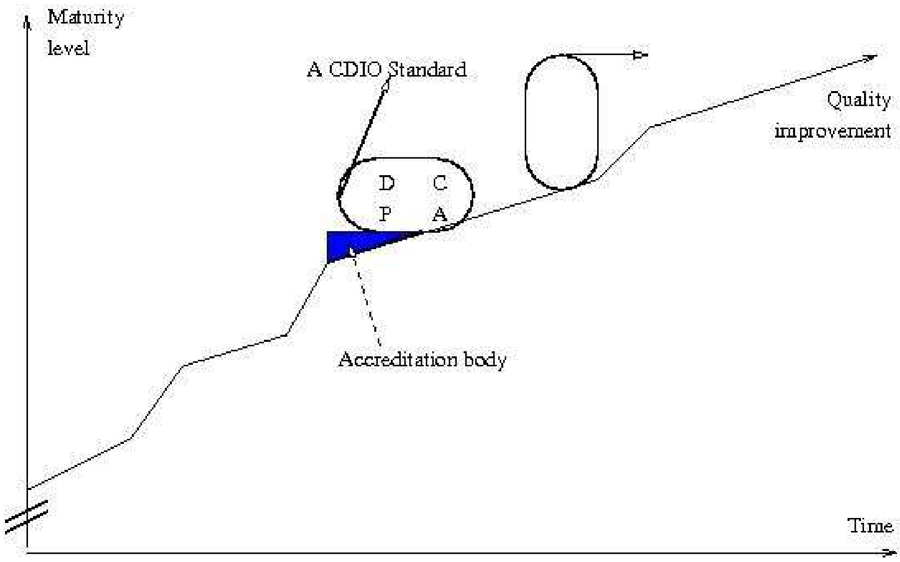

Figure 2: Step by step introduction of CDIO standards under a cascade cycle.

Process models are needed to better organize and run large projects. They need however to be adapted to specific settings. For example, based on a PDCA (plan-do-check-act) quality control cycle, we are today able to model the process in place in our institutional context, where the wheel appears to be more ovoid with its own gravity, our national accreditation body being our main wedge to secure improvements. In fact, with a 6-year timeframe for accreditations, relying on CDIO standards permits more flexibility and continuity over time (cf. Figure 2). CTI in a Deming cycle could be regarded as a wedge, particularly due to its relative inertia in evolution. Whatever Telecom Bretagne maturity levels on each CDIO standards are, its programs are recognized of high quality. The national rankings, the accreditation body, as well as employers opinion on the programs proves it, and Telecom Bretagne is largely recognized in France as innovative in pedagogy and project-based learning, among others… (Telecom Bretagne is the main organizer of the French speaking international Colloquium on Pedagogy Questions in Higher Education since 2001). Moreover, for CDIO self-evaluation, our maturity levels in semester projects and classical minors and majors are non uniform: the dual approach of our curriculum (integrated projects and more compartmentalized integration of disciplines) tends to objectively undervalue the ratings on some of the standards. The stepwise introduction and acceptance of the CDIO standards since 2008 in our institution, first under a cascade cycle, now enable us to prepare a deeper continuous improvement based on a more agile iterative cycle thanks to CDIO standard #12. For this, students are now the strongest change agents.

FUTURE DIRECTIONS

Cross-evaluations as a Complement to Accreditations

Self-evaluation, conducted internally by deans, e.g. by academic deans, is not so often objective. It is most often hard for an institution to identify its own weaknesses due to a lack of detachment. On the opposite, evaluations can be fruitfully conducted by groups external to the program, but belonging to a similar type of HEI. This approach is beneficial for both the institution evaluated which will get a more objective view on its strengths and weaknesses, and for the evaluation team which may identify best practices that can be useful for its own institution. Also, recently, some cross-evaluations have been introduced by institutions from the CDIO Nordic region. As the only French CDIO collaborator, Telecom Bretagne would gain to cross-evaluate its two programs with others higher education institutions in engineering, e.g. EUR-ACE or CTI accredited at Master levels. The results will certainly receive a better acceptance from teaching staff, as being more neutral.

Student-evaluations as a Strategic Crowbar

At Telecom Bretagne, a semester project has been initiated in Spring 2012 (5 students, approx. 120h working time each) to evaluate the generalist program thanks to the CDIO standards. Currently, several interviews, based on elaborated questionnaires per standards, are being conducted with main stakeholders in the institution. The results will allow, even from a student perspective to be taken with a pinch of salt, to compare the actual self-evaluation rankings and maybe pinpoint original weaknesses.

Multi-accreditations and QA

Nowadays, there are several criteria proposed for accreditation. Accreditation boards tend more and more to integrate quality assurance perspectives in those criteria. However, for purposes of representing various accreditation bodies' requirements, diversity of disciplines, and specific national (or even traditional) contexts, no global and unified framework for higher education has emerged (e.g. meta-syllabus). But higher engineering institutions tend to juggle with those criteria when at the frontiers of several accreditation bodies. For example, in France or Europe, it now exist labels for sustainability and social aspects for engineering programs. Lastly, business constraints (e.g. costs, globalisation) and incitements to collaborate more and more formally with potential partners (e.g. for deeper visibility, ratings and rankings, student exchanges, etc.), sometimes lead educational institutions to align with various educational systems, or even frameworks [10], at the risk of creating inconsistency and interoperability problems.

As a complement, to maintain the pace with the evolution of societal and educational environments and missions, the CDIO framework should remain a dynamic tool: Firstly, the framework itself may need to be updated (e.g. see recent changes of standard #2 syllabus relating to sustainability, leadership and entrepreneurship issues [14], interrogations on a 13th standard, etc); Secondly, educational institutions must often adapt the CDIO framework to their own reality depending on quality requirements (e.g. criteria defined by professional or governmental accreditation boards, specific quality management models). The interoperability of the CDIO framework with accreditation criteria is to be addressed thanks to metamodels [15] so as to minimize coherency problems.

CONCLUSION

Educational system design, transformation, and improvement involve many stakeholders. Most often, those stakeholders should prefer to navigate in a flexible and progressive manner so as to keep the pace. The French higher engineering education system provides an interesting study sample with its traditions. This paper presents, analyses, and synthesizes the progressive introduction of some of the CDIO standards in a recognized French *Grande Ecole*. It contributes to clarifying quality management issues based on the CDIO standards so as to face resistance to change. The first difficulty for our institution was to define a detailed syllabus of learning outcomes for generalist engineers as found in the French *Grande Ecole* system, as this is rather difficult and largely subject to critics if formalized internally. Syllabus proposed by classical accreditation bodies are rather abstract and do not facilitate the alignment of program courses at a fine grain. They are however largely recognized by the teaching staff since they are issued by the authorities. After several years of experiments and iterations in defining its own syllabus, Telecom Bretagne was confronted to a problem of granularity, personal staff interest and loss of energy. The CDIO syllabus standard #2, with its hierarchical levels, allowed us to overcome our difficulties, ensure a better coverage of the outcomes and prepare constructive alignment [4]. Based on those pillars, introduced via a cascade process model, the door is open for the next standards before relying on a more agile model for continuous improvement.

The approach presented in this paper is relevant to beginners in the CDIO approach, but perhaps also for those who already adopted the CDIO approach, but find it hard to keep the flame due to a too rapid introduction. From our experience and context, to face resistance to change and conservatism, the CDIO framework should remain a dynamic tool and be presented step by step to the teaching staff. Educational institutions must often adapt the CDIO framework to their own reality in order to take into account their own constraints (e.g. distinct educational criteria defined by professional or governmental accreditation boards). Efficient continuous improvements need to rely on a managerial and career recognition of participating staff. The publish or perish dilemma regarding scientific research is largely limiting the motivation for engineering education, self-efficacy and devotion of (assoc)professors. This is the reason why Telecom Bretagne recently adopted teaching and educational competences as parts of the criteria to be fulfilled for promotion as Professor.

A cascade or V process model is a classical basis to lay the foundations of architectures, as proposed by the systemic CDIO framework. Operating under an agile model is more reactive but subject to refactoring: after several evolutions or additions, the foundations can be less adapted and aligned with newly requirements, thus possibly requiring an other architectural style. The competency requirements of Europe in the 2000's prompted profound reforms in higher engineering programs. Telecom Bretagne next national CTI accreditation process, for 2013-14, is in the continuity of our process model. However, for the next coming years, some profound reforms could have to be conducted. As an example, the recently created AERES national agency might participate in the accreditation of engineering degrees in France. As another example, before 2011-12, Computer Science did not exist in French programs below K12 [16]. Next year, French preparatory schools will now have to address this discipline on a compulsory basis and consequently reform their programs. Accordingly, in 2014-15, engineering schools will admit new freshmen, for whom the actual Computer Science and Computer Engineering courses will have to be redesigned.

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