CURRICULUM RENEWAL AT TWO UNIVERSITIES IN CHILE USING THE CDIO SYLLABUS

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Abstract

This paper presents a methodology based on the CDIO[1] model, implemented to analyze the requirements for the basic common core of the engineering programs at Universidad de Chile and Universidad Católica de Chile.

To propose models for the definition of new curricula and course contents, Competences-Contents tables were used, at the levels of basic sciences, core engineering fundamentals and advanced engineering fundamentals. The main methodological reference used in both schools was based on the CDIO Syllabus, which provides an extensive listing of skills with different levels of detail, being an excellent source for the analysis of competences, and allowing the addition of local competences that reflect the identity of a particular university.

As result of the analysis both schools agreed on a translation of CDIO Syllabus, evaluated their current curricula and changes were proposed in order to renew the curricula having the competences as the main goal to achieve. Both schools will put under consideration a unified syllabus as a national reference model.

Keywords: CDIO Syllabus, curricula renewal, basic science and mathematic competences.

1. Introduction

The multiple innovations being generated nowadays in engineering education, encouraged by accreditation processes, like ABET2 in United States and the Bologna process in Europe, have emphasized a wide range of skills and competences that graduates must achieve over the classic course contents focus. This context was a great opportunity to start the reflection about engineering programs in Chile, taking into account these new challenges.

The engineering programs at Universidad de Chile (UCH) and Universidad Católica de Chile (UC), the leading Schools of engineering in Chile, are structured with three cycles: basic common core, bachelor, and engineering diploma. For each level it is necessary to determine the required general and specific competences. The starting point to achieve this goal was the preparation of professional profiles for each engineering diploma, considering the current and future needs of the professional environment and the employability.

To propose models for the definition of new curricula and course contents, Competences-Contents tables were used, at the levels of basic sciences, core engineering fundamentals and advanced engineering fundamentals.

The main methodological reference used in both schools was based on the CDIO initiative, especially the CDIO Syllabus, which provides an extensive listing of skills with different levels of detail; it is an excellent source for the analysis of competences, and it allows for the addition of local competences that reflect on the identity of a particular university.

This paper presents a methodology based on the CDIO model, implemented to analyze the requirements for the basic common core of the engineering programs at UCH and UC.

2. Table with assignments of levels at Universidad de Chile

In UCH, to date, the analysis has been done primarily by faculty members, who had a permanent dialog with students and with graduates. Because at UCH the generic competences have been defined globally for all its programs, the work focused on those specific competences required for engineering graduates.

Given the context of the reform of the bachelor program and its basic common core in the School of Engineering and Science at UCH, the work focused on the first section of the CDIO Syllabus. One of the main results of this part of the work was the participation of academics from all thirteen departments of the school, which are users of the knowledge and skills obtained by students in the common core (currently of 5 semesters).

2.1 Levels of proficiency

As proposed by the CDIO model, for the assignment of the levels of proficiency in skills, we used a scheme of tables, with competences in the rows and the levels of achievement in the columns. The first challenge was not only the translation of the competences but of the levels of proficiency. The CDIO model propose a progressive scale from 1 to 5, the higher value meaning higher achievement. In the UCH adaptation of the model, a new column assigned with the 0 level of proficiency was inserted, meaning that this competence is not necessary. In addition, explanations were incorporated for the better comprehension of direct translation to the level of proficiency.

In each cell, the evaluator could mark with an "x" the expected level of proficiency. Once all the answers were received from the departments, frequencies (histogram) and averages were computed for each skill.

2.2 Translating the Syllabus and Building the tables with common core contents

The CDIO Syllabus model proposes four different levels: level 1.x for technical knowledge and reasoning, level 2.x, 3.x and 4.x for personal, interpersonal and CDIO competences. At UCH the work was split in two parts. The first devoted to the basic engineering knowledge (1.x) and the second one for the other three sections.

For level 1.x six basic subjects were selected: Physics, Mathematics, Chemistry, Computer Science, Economics and Biology. Each department offering these subjects had to produce a listing, with two levels of detail, of the subjects that could be taught in the common core. It was explicitly pointed out that this listing should not necessarily follow the contents of courses in the current curriculum, but should include all those that should be present, including some (like Biology) that are not currently part of the common core.

The table with the levels 2.x, 3.x y 4.x was distributed to the different departments with the translated CDIO Syllabus, without making any changes to it.

Table 1.x was distributed to the different departments to assign levels of proficiency. Each department had a professor to coordinate this task and each one chose its own method. The most used one was to meet in small groups of professors who discussed and tried to reach consensus. The professors were usually teachers of the courses after the common core. Each department in charge of each of the six basic subjects selected had the opportunity to present their proposed list of topics, on the other hand the others department were allowed to add additional topics.

After all the assignments had been received the frequency and averages for each topic were computed, like shown in the example 1:

Example 1: "Frequency of expected levels of proficiency"

			Expected levels of proficiency (mark with an x)					
		0	1	2	3	4	5	Ave.
Chemistry	Atomic structure	0	0	1	10	2	0	3,1

This example shows that 10 departments assigned to "Atomic structure" a level of proficiency 3 (*to be able to understand and explain*), 2 departments assigned a level of 4 and only 1 the level 2. The average considered as weight the number of department assigning each level.

Alternatively, the average was also computed using as weight the number of students in the departments that assigned each level. With few exceptions, the result did not change significantly.

Once the table was filled with the frequencies, a full analysis and a general overview of the common core was obtained. With this in hand it was possible to analyze the outline of different courses proposed and in some cases it was useful to determine if a given course should be included in the common core.

Throughout this process the tables were published on a webpage and were updated as the result were submitted by the departments. In this way they were always available to be seen by all interested professors or students.

Figure 1 shows the diagram of the process of analysis of competences in the level of basic knowledge at UCH.

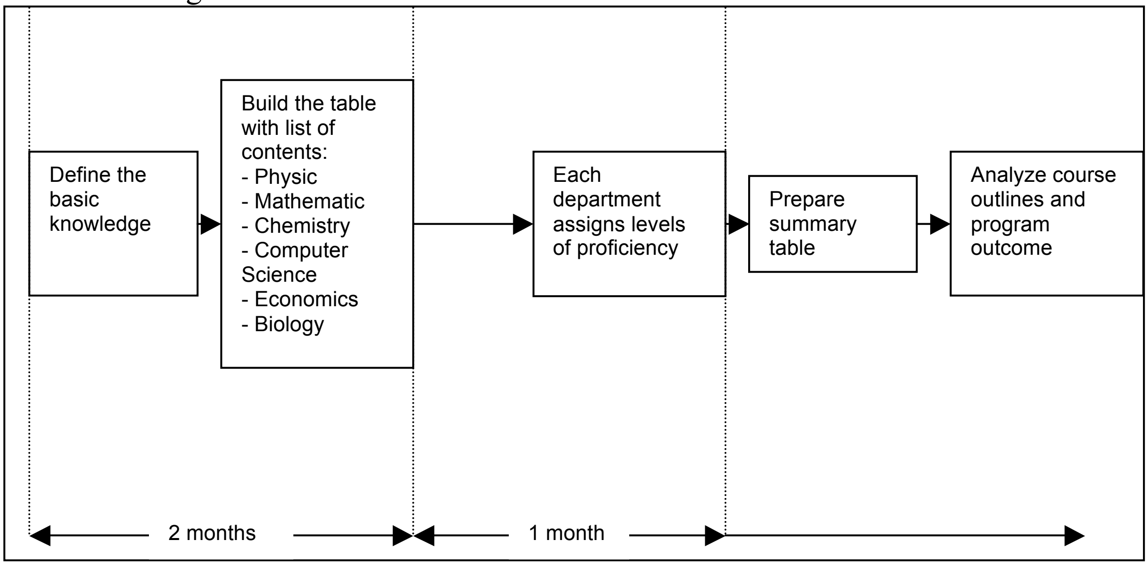


Figure 1. Process of analysis of competences at Universidad de Chile

The table with levels 2.x, 3.x y 4.x is currently being analyzed by the departments. This process has been somewhat more difficult because some competences in the list when translated were not understood by the professors, and this delayed the process making it take more time than level 1.x. Example 2 shows one change introduced for the analysis that was to record two assignments: both the current level of proficiency of the students and the expected one.

Example 2: "Double assignment: current and expected levels of proficiency"

		Current and expected levels				
Personal Skills and Attributes	0	1	2	3	4	5
Time and Resource Management			Y		X	

The Y is used to indicate the current level of proficiency of the students (in the example the students are proficient at the level "to be able to participate in and contribute to"), while the X indicates that the students are expected "to be skilled in the practice or implementation".

The idea of this double assignment is to identify the more important gaps; in other words, to obtain the list of the competences with bigger deficits, to focus on them.

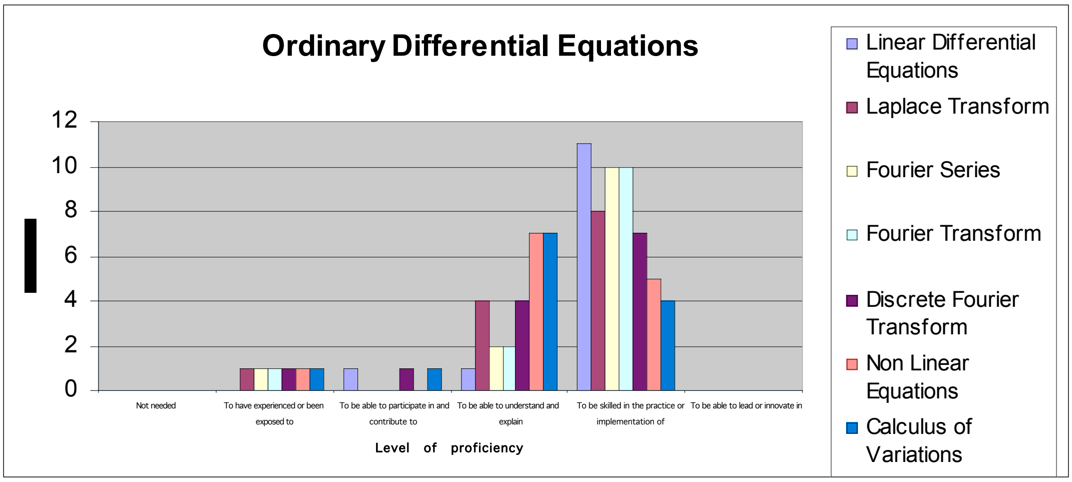
It is important to mention that some of these weaknesses are being covered through different initiatives like new courses[3] and special activities[4] for freshmen

2.3 Analysis of the results

Once the table with assignments of levels of proficiency was completed, the result was a general overview of the opinions of the departments. This was used to perform an analysis of the contents of the various courses proposed, and in some cases it was useful to define the inclusion or not of a given course in the common core.

For example, for the course “Ordinary Differential Equations” the histogram of the level of competences assigned to some of the topics of the course looks like the one shown in Example 3.

Example 3.



3. Fitting the syllabus to the institutional context at Universidad Católica de Chile.

The College of Engineering at UC is going through a curricular reengineering process, and the goals proposed to the new curriculum are:

a) To change the present paradigm towards a curriculum based on outcomes.
b) To fulfill the ABET EC2000 criteria.
c) To improve the efficiency of the education and learning process.
d) To meet the industry requirements.
e) To improve the international exchange of students and doubles degrees.

This process involves all the engineering majors, and every aspect of the curriculum is being reviewed and evaluated: years of study, number of credits, design component, curriculum structure, size of the lectures, learning methodologies, learning assessment and financial issues.

The work made to date in the College of Engineering at UC, has been based primarily on creating a methodology to carry out the reengineering process and to create the administrative structure to support the change. The methodology was based, on the one hand, on the work done by the School of Engineering of the University of Arizona[5] which is based on the QFD technique (Quality, Function, Deployment), and on the other part, it was based on the methodology of the CDIO coalition.

The first step was to fit the CDIO syllabus to the institutional context and on defining the competences of the core engineering fundamentals for all the undergraduate majors. The first change to the syllabus was the modification of the points 1.1, 1.2, and 1.3 into points 1, 2, and 3 of the new syllabus. This modification allowed a better reaction of the faculty, because it sets at a comparable level of detail the technical and professional competences. This is an important issue in Chile because the professional competences are seen as not real engineering by a group of faculty. However, the professional competences are highly required by the industry, and the CDIO syllabus has helped in the faculty cultural change that we are carrying on.

The main points of the new syllabus CDIO-UC are:

1 Knowledge of Underlying Sciences
2 Core Engineering Fundamental Knowledge
3 Advanced Engineering Fundamental Knowledge
4 Personal and Professional Skills and Attributes
5 Interpersonal Skills: Teamwork and Communication
6 Conceiving, Designing, Implementing and Operating Systems in the Enterprise and Societal Context

These points were translated to Spanish as:

1 Conocimientos en Ciencias Básicas
2 Fundamentos de la Especialidad
3 Conocimientos Avanzados de la Especialidad
4 Habilidades y Atributos Personales y Profesionales
5 Habilidades Interpersonales: Comunicación y Trabajo en Equipo
6 Ingeniería en el Contexto Organizacional y Social

An entire translation to Spanish of the original CDIO syllabus, made by UCH and UC, can be found in the appendix of the article.

On the other hand, some new competences were added to the Syllabus according to the mission of the University, the mission of the College, and finally our engineering culture. In section *4. Personal and Professional Skills and Attributes*, points 4.6, 4.7, 4.8 and 4.9 were included, as shown next.

4 Personal and Professional Skills and Attributes
- 4.6. Ability to adapt to market and industry requirements
  - 4.6.1. Value and understanding of other engineering majors
  - 4.6.2. Willingness to professionally develop in other engineering areas
  - 4.6.3. Capacity to apply engineering tools in other areas of knowledge
  - 4.6.4. Capacity to adapt to change
- 4.7. Respect or commitment to the Christian principles
- 4.8. Preoccupation for the most needed
- 4.9. Preoccupation for the environment

Other major change was made in the section *6. Conceiving, Designing, Implementing and Operating Systems in the Enterprise and Societal Context*, including an explicit point about the evaluation and control of systems and processes, closing the loop of conceive, design, implement and operate.

6 Conceiving, Designing, Implementing and Operating Systems in the Enterprise and Societal Context

6.7. Evaluation and control
   6.7.1. Data collection
   6.7.2. Analysis and process control
   6.7.3. Capacity to draw conclusions and propose actions
   6.7.4. Management of continuos improvement

Once the syllabus was defined, each Department had to delineate the core engineering fundamentals for each major (section 2 of the syllabus CDIO-UC) on the basis of an exhaustive review of the present curriculum and on the detailed comparison with similar programs on a world-wide level, and with competences defined by independent organisms such as ABET and NCEES.

Once the engineering fundamental competences were defined, the Departments had to define the basic sciences competences needed by the students to fulfill the engineering core. Finally the competences of section 1 of the syllabus CDIO-UC were detailed at a central level with the aim of assuring that every student has the skills and tools to develop an enduring learning of the engineering core for each major.

4. Conclusions

Using a methodology based on the CDIO Syllabus in a Chilean context allowed a reflection compatible with the identity and tradition of both universities, which increased the participation of professors. This successful experience may serve as reference for other universities in Chile and Latin America that are beginning processes of reflection about their curricula.

Both Schools are currently working to create a model syllabus, and use it as a basis for a national survey of stakeholders. The survey will have two parts: one common to all the engineering majors, related to the professional skills, and one specific to each major, related to the technical skills. The results of this survey will help to determine the expected level of proficiency for each skill in the syllabus.

5. References

[1] www.cdio.org
[2] www.abet.org
[3] Poblete P. and Vargas X. "Designing a First Year Introduction to Engineering Course" Sixth international workshop on Active Learning in Engineering Education. June 2006, Monterrey, México, pp 366 – 375.
[4] Poblete P., Vargas X. and Celis S "Viviendo la ingeniería desde el primer día de clases: dos experiencias en la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile." Proceedings of XX Congreso SOCHEDI, Chile 2006.
[5] College of Engineering Educational Assessment Plan, University of Arizona http://academic.engr.arizona.edu/engradmin/programassessment/AssessmentPlan.htm

6. Appendix – CDIO Syllabus in Spanish

1 CONOCIMIENTOS TÉCNICOS

1.1. CONOCIMIENTOS EN CIENCIAS BÁSICAS [a]

1.2. CONOCIMIENTOS EN LOS FUNDAMENTOS DE LA ESPECIALIDAD [a]

1.3. CONOCIMIENTOS AVANZADOS DE LA ESPECIALIDAD [k]

2 HABILIDADES Y ATRIBUTOS PERSONALES Y PROFESIONALES

2.1. SOLUCIÓN DE PROBLEMAS Y RAZONAMIENTO INGENIERÍL [e]

2.1.1. Identificar y formular problemas
2.1.2. Crear y usar modelos
2.1.3. Estimar y analizar problemas de forma cualitativa
2.1.4. Analizar problemas bajo condiciones de incertidumbre
2.1.5. Solución de problemas y recomendaciones

2.2. EXPERIMENTACIÓN Y CONDUCCIÓN DE INVESTIGACIONES [b]

2.2.1. Formular hipótesis
2.2.2. Realizar búsqueda de literatura impresa y electrónica
2.2.3. Conducir investigaciones experimentales
2.2.4. Probar y defender hipótesis

2.3. PENSAMIENTO SISTÉMICO

2.3.1. Pensar holísticamente
2.3.2. Analizar la interacción de componentes y nuevos elementos
2.3.3. Priorizar y sintetizar
2.3.4. Análisis dinámico
2.3.5. Resolver realizando juicio crítico y alcanzando balance entre los trade-off

2.4. HABILIDADES Y ACTITUDES PERSONALES

2.4.1. Iniciativa y disposición de aceptar riesgos
2.4.2. Perseverancia y flexibilidad
2.4.3. Creatividad
2.4.4. Pensamiento crítico
2.4.5. Conciencia de competencias personales
2.4.6. Curiosidad y disposición a aprender de por vida [i]
2.4.7. Gestión del tiempo y recursos

2.5. HABILIDADES Y ACTITUDES PROFESIONALES

2.5.1. Ética profesional, integridad y responsabilidad [f]
2.5.2. Comportamiento profesional
2.5.3. Planificación proactiva de su carrera profesional
2.5.4. Disposición a mantenerse actualizado en el mundo de la ingeniería

3 HABILIDADES INTERPERSONALES: COMUNICACIÓN Y TRABAJO EN EQUIPO

3.1. TRABAJO EN EQUIPO [d]

3.1.1. Capacidad de formación equipos efectivos
3.1.2. Capacidad de gestión de equipos
3.1.3. Identificar y desarrollar habilidades para el crecimiento y evolución del equipo
3.1.4. Capacidad de liderazgo de equipos
3.1.5. Capacidad de trabajar en distintos tipos de equipos y colaborar técnicamente

3.2. COMUNICACIÓN EFECTIVA [g]

3.2.1. Analizar situaciones y elegir estrategias comunicacionales

3.2.2. Construir estructuras comunicacionales adecuadas
3.2.3. Capacidad de comunicación escrita efectiva
3.2.4. Capacidad de comunicación por medios Electrónicos/Multimedia
3.2.5. Capacidad de comunicación por medios gráficos Gráfica
3.2.6. Capacidad de comunicación por presentaciones orales

3.3. COMUNICACIÓN EN IDIOMAS EXTRANJEROS

3.3.1. Capacidad de comunicarse de forma oral y escrita en Inglés
3.3.2. Capacidad de comunicarse de forma oral y escrita en otros idiomas

4 CONCEBIR, DISEÑAR, IMPLEMENTAR Y OPERAR SISTEMAS EN EL CONTEXTO ORGANIZACIONAL Y SOCIAL

4.1. CONTEXTO SOCIAL Y EXTERNO [h]

4.1.1. Comprender el rol y responsabilidad del ingeniero
4.1.2. Comprender el impacto de la ingeniería en la sociedad
4.1.3. Conocer las regulaciones sociales sobre la ingeniería
4.1.4. Conocer el contexto histórico y cultural
4.1.5. Comprensión de la actualidad y valores contemporáneos [j]
4.1.6. Desarrollar una perspectiva global

4.2. CONTEXTO ORGANIZACIONAL Y DE NEGOCIOS

4.2.1. Apreciar diferentes culturas organizacionales
4.2.2. Reconocer la estrategia empresarial, metas y sistema de planificación
4.2.3. Emprendimiento
4.2.4. Trabajo efectivo en organizaciones

4.3. CONCEBIR Y APLICAR INGENIERÍA A LOS SISTEMAS [c]

4.3.1. Definir requerimientos y metas del sistema
4.3.2. Definir funciones, conceptos y arquitectura del sistema
4.3.3. Desarrollar modelos del sistema que permitan su evaluación
4.3.4. Desarrollar la planificación del proyecto

4.4. DISEÑO [c]

4.4.1. El proceso de diseño
4.4.2. Conocer las fases y enfoques alternativos de diseño
4.4.3. Utilización del conocimiento técnico en el diseño
4.4.4. Diseño disciplinario
4.4.5. Diseño multidisciplinario
4.4.6. Diseño multi-objetivo

4.5. IMPLEMENTACIÓN [c]

4.5.1. Diseñar el proceso de implementación
4.5.2. Concebir el proceso de fabricación de Equipos
4.5.3. Concebir el proceso de Implementación de Software
4.5.4. Diseñar la implementación e integración de los procesos
4.5.5. Probar, Verificar, Validar y Certificar
4.5.6. Gestión de la implementación

4.6. OPERACIÓN [c]

4.6.1. Diseñar y optimizar operaciones
4.6.2. Entrenamiento y capacitación de las operaciones
4.6.3. Soporte durante el ciclo de vida del sistema
4.6.4. Reconocer la evolución y mejoramiento del sistema
4.6.5. Manejo de fin de vida útil y desechos
4.6.6. Gestión de operaciones