THE CDIO CURRICULUM IN ELECTRONICS ENGINEERING AT UNIVERSIDAD JAVERIANA - COLOMBIA

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ABSTRACT

The convergence of questions about teaching and learning among MIMESIS, the research Group from Pontificia Universidad Javeriana, and the CDIO Initiative led to reflection about electronics engineering curriculum. The process initiated as a result of the above has involved four stages: socialization of the initiative, adaptation of the CDIO syllabus, analysis of the body of knowledge, design of the curriculum structure using Backward Design technique, and the integration of competences defining a gradual process in their development. Should be highlighted the support given by the university administration, deans and directors of school of engineering; It is also relevant to point out collaboration provided by students, faculty, local industry, alumni and some high schools. During this process also managed to strengthen the relationship with the stakeholders. Today, motivated by the experience of electronic engineering, the civil, industrial and software engineering programs at the University have begun their own reflections oriented by the MIMESIS group. The present work shows the development of curricular reflection and the methodology implemented, which allowed us to formulate and to integrate, innovative curriculum in the Colombian context. Also is presented here the proposal of a teaching and learning Center for engineering that will support the CDIO standards.

KEYWORDS
Curricular reflection, stakeholders, CDIO adaptation, Electronics Engineering.

INTRODUCCIÓN

Questions about engineering education and the related learning processes have been present in the reflection of the Electronics Department at the University for several years. In 1995 the creation of a research group was motivated by the characteristics of the students entering to electronic engineering program, and the less effective teaching and learning practices that we were implementing. The group concentrated its effort in the review and adoption of new and more efficient ways to achieve a better process of learning by students. This group is called MIMESIS and its creation was the formalization of a working group which included some professors from the Department of Electronics and the Faculty of psychology.

The research group found the possibility of implement new practices and testing them in the courses of the area of digital techniques. The group modified the methodology of classroom in most of the courses in the area. MIMESIS leaned towards a methodology in which active learning, learning through projects, work in group, and others are prioritized. In this model teacher is a guide, not the center of the course process. The experiences in these courses and the results obtained by the students motivated us to review the work of other educational organizations, finding some similarity between our work and the proposals of the CDIO initiative. At that time, faculty was concerned about the student’s academic results after the curriculum change in 2003. This change had been motivated by the reform of the Ministry of national education. As consequence the process of change was very quickly without a formal study and without agreement by the teachers of the Department on this issue.

Previous approaches motivated us to learn more about the CDIO Initiative, and to be part of it; therefore we began a reflection process about our program. This reflection has resulted in a curriculum reform with huge implications, not only at the level of the program and faculty, but also at the School of Engineering and the University levels.

This paper describes the experience of curricular reflection about the program of electronic engineering, within the framework of the CDIO philosophy. We present the general characteristics of the current curriculum and highlight critical points which could be susceptible to improvement. Initially, we show the stage of socialization of the initiative and the diagnosis of the current state of the program, followed by the adaptation of the syllabus CDIO, as well as the analysis of the body of knowledge and the structuring of the new curriculum. We finish with the validation by stakeholders.

REFLECTION ON THE CURRENT CURRICULUM

The current curriculum was designed for 5 years with 174 academic credits and 62 courses. Electronics Engineering at Universidad Javeriana is recognized in the country as one of the highest quality programs.

However, some issues have been identified; among them we can highlight:

- Engineering introduction course in first semester.
- Courses in physics and mathematics from first semester.
- Starts disciplinary formation from fourth semester.
- Final project at the end of the program
- Strong academic load, related to the total number of courses.
- Traditional practices of teaching, assessment and work spaces.
- It has balance between the theoretical topics and practical ones.
- Weak relationship with industry. Lack of motivation of students during the program.
- Low level of retention of students.
- Subjects of humanistic areas are disconnected from the discipline.
- Absence of training in skills different to disciplinary ones.

Taking into account the above, and making an analogy with a company, we can argue that the goal of the review and the restructuring of the curriculum is the improvement of education, as our final product. We know that our final product is a graduate with structured education which must enable alumni to engage in the work field as an engineer, i.e., with the ability to conceive-design-implement-operate products, processes and complex systems with added value in modern and team-based environments [1].

To achieve this goal it is important to count with the electronic engineering program stakeholders; all those who in some way, internally or externally, are related to the process of education. Therefore, the inner group is composed by the directives, faculty and students and external group is integrated by industry, graduates and high schools.

In the first stage with internal stakeholders, we diagnose the current situation of the program, creating awareness of the need to change and from hence we called together a collaborative work for the construction of concrete proposals. The second stage, with external stakeholders sought to validate the proposal and make a clear projection to know where we are heading for through the educational process, according to the needs of the context and the challenges arising from the projections to 10 years in electronic engineering programs in Colombia.

SOCIALIZATION AND DIAGNOSIS

We started with a general socialization of CDIO philosophy; this socialization came to all levels of the University, faculty, and departments providing services to the program and directives. Widespread reactions were positive and the initiative generated great expectations.

The managers of the University supported the project, recognizing that this could mean structural reforms. Their support was evident through the continued interest accompanying and receiving advance reports and giving the resources necessaries to implement the reflection about the curriculum. A group of 14 volunteer teachers with allocation of time in their work plans was initially created for the reflection and curriculum planning.

After socializing, we conducted two workshops with all faculty; the first one asked where the electronic engineering program was heading for, starting based on a reflection related with the history of education in engineering. The second workshop sought to inquire if all teachers understood in the same way the meaning of the construction of product, process or system and generated a reflection on the necessary skills and competencies to enable an engineer to perform professionally [2]. The reflection was focused in the questioning about what an engineer makes in his professional career, so that we could define some characteristics of the Colombian context which should be present in the process.

The group concluded that the cycle of construction of product is a fundamental task of graduate engineers and therefore of the education process. There are essential skills in addition to knowledge discipline, like innovation capacity, skills to communicate ideas, and manage projects; all of these one are framed in the real context of the country, emphasizing the social and environmental commitment [3]. We highlighted the need to encourage entrepreneurship, looking for our country as developer of technology, and not only as consumer. It became clear that the project that we are implementing is not only to build enterprise, it is an attitude to life, to work, where new ideas, and the possibility of leaving common solutions, as well as the opening to take on challenges, are part of the nature of engineer.

It is important to mention that before we began our process and during the development of the same, we have been supported by Dr. Doris Brodeur, CDIO leader, who through workshops, discussions and written material enabled us to achieve dominance of the Initiative philosophy and the methodology to be followed to turn our program into a CDIO program. It is also important to note that our participation in different events organized by the Initiative and the first meeting of the Latin America Region that was organized by us, have been useful in our reflection process.

Parallel to working with faculty, we began the approach to student's groups. In courses of the area of digital techniques, new methodologies were implemented in coherence with the proposal of change [4]. Each semester assessment processes were made in a judicious way. The changes were generally well received. Once collected the information of all stakeholders, and as soon as the CDIO philosophy became known by the faculty, we began the debate on competences and the graduate profile of electronic engineering program, by adapting the CDIO syllabus.

CDIO SYLLABUS ADAPTATION

For the adaptation of the CDIO syllabus the group of 14 teachers, was divided into 2 teams, so that the process of discussion would be more productive. The meetings were held twice a week for 6 months. Each session lasted 2 hours. The methodology used in this reflection was the work in teams about each subject in order to get consensus. Then, the two teams met to analyze only those in which there were discrepancies. We started with the personal and professional competencies. The first task of the group was the syllabus translation into Spanish and the analysis of the meaning of each one of the phrases that make up the syllabus. It was shared and discussed by the two groups until we reach the translation everyone was in agreement. All the skills were subjected to this treatment in the same way.

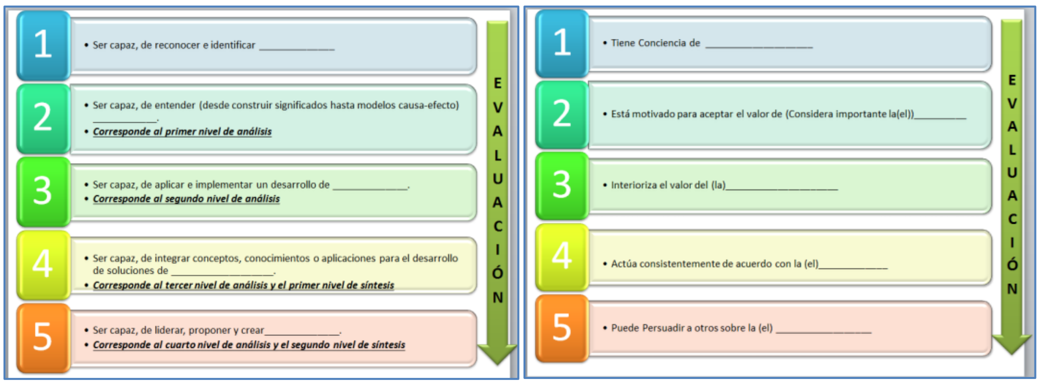

Figure 1. Scales of knowledge and value

Subsequently, we continue with the weighting of each of the skills, prior discussion of scales of knowledge and value provided by the CDIO initiative. The discussion of these scales was completed in some modifications on them as shown in the Figure 1. We attach the version in Spanish for precision in the language. These scale modifications were adapted better to our process. With these modified scales the weighting of each of the competencies was made following the same methodology; i.e., each group had its own weighting and then in a plenary meeting were discussed only those items on which there was disagreement until we reach a consensus. Results are shown in Figure 2.

ANALYSIS OF BODY OF KNOWLEDGE

After the adaptation of the Syllabus competences (numerals 2, 3 y 4), we began the revision of the body of knowledge of electronic engineering, i.e., disciplinary knowledge and reasoning. In this stage each one of the areas of Electronics Department, made a study of the status of their own knowledge area and using the Backward Design technique each area generated a proposal about what a student should know after obtaining his electronic engineering degree [5]. This work took about a month, in which faculty now gathered in their respective areas, drew up a list of the different topics that a professional should know, also indicating the order or precedence of each of them. Furthermore each group indicated that other areas knowledge was required to get learning in the subjects they teach. With these inputs, the group made a graph showing all the items proposed by each of the areas and their respective requirements. This information led a discussion by all teachers and let us to have clarity about the need to make a substantial reform in the current curriculum.

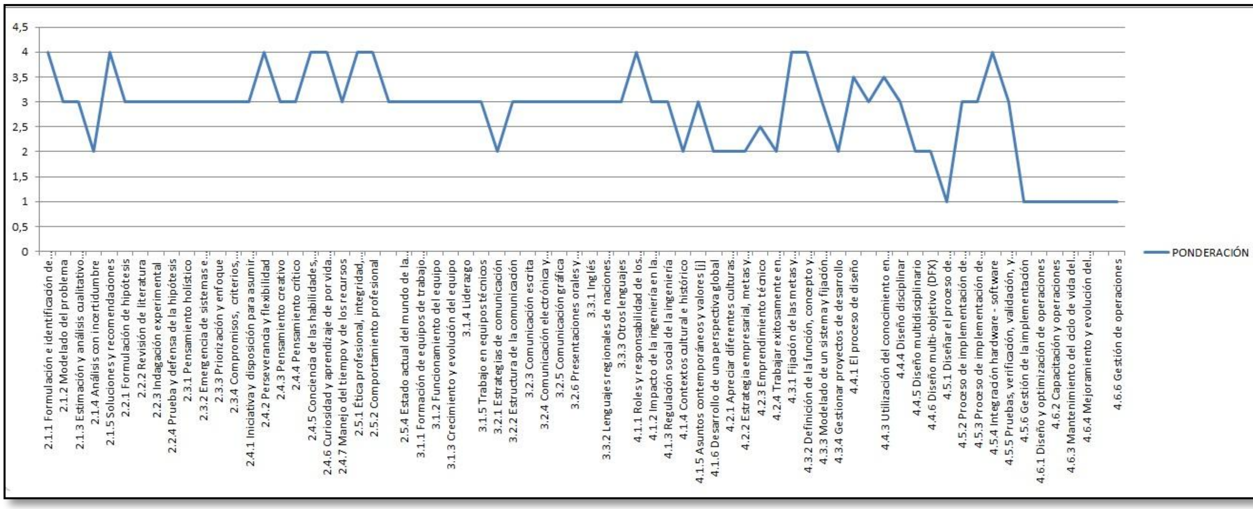

Figure 2. CDIO Syllabus Adaptation.

Within the causes that led us to the need for reform mentioned above, it is worth noting:

- In the first 4 semesters of study, students receive little training in electronic engineering.
- During the first semesters, students receive courses in mathematics and physics, but there are no moments in which we explain them how, why and where those concepts are applied in engineering.
- The groups identified that a very important issue for all is the study of the "signals", but that the first course that talks about this subject is in sixth semester. In addition, because his mathematical components, “signals” is a theme that allows us to make a link between mathematics and engineering since the beginning of the studies (first semester).
- A source of employment for our students is the area of communications, and we find that its corresponding subjects are at the end of the program very isolated from the other courses.
- Because subjects of the digital area begin in sixth semester, other areas have problems to teach their subjects, since these themes are required before.
- Some abilities of the numerals 2, 3 and 4 of the CDIO syllabus, are included in some of the courses of the curriculum, but none of them is made explicit in the content of the course and these skills are not evaluated. There are some courses that work some of them such as ethics, but it is an isolated subject.
- The number of courses of the curriculum is very high, which leads the student to take many courses each academic term and leaves him little time for his autonomy and a good learning.
- The program has an oversized offer of 9 areas of emphasis for the fifth year.

The curriculum reform is inspired by a desire for continuous improvement of our formation processes [6], the above problems are some of the critical points susceptible to a change.

THE NEW CURRICULAR STRUCTURE

From the discussions of the group with respect to the body of knowledge and the adaptation of the syllabus, we were working on a new curricular structure. The first point that we began to discuss were the integrating projects, making brainstorm about the type and level of complexity taking into account that the program has duration of 5 years. This led us to define a basic objective for each of the years of the curriculum, in the following way:

- Year 1: motivation
- Year 2: integration of engineering and basic sciences
- Year 3: solving problems with electronics
- Year 4: integration and application
- Year 5: autonomy and flexibility

After introducing these objectives, we decided to create one integrator project per year. Considering the educational objectives and the projects characteristics as basis [7], we began to build the curriculum including the knowledge and skills that students should develop each academic period, so that they can develop the proposed projects.

This process took other considerations, such as:

- The innovative methodologies in work spaces, which allow reducing the number of subjects and empowering the student.
- The gradual learning and personal, interpersonal skills and CDIO, determining the scope of each of the periods. In this sense every competence of the syllabus has a level of scope for each year.
- Some issues are really essential for the formation of the student, especially looking at the content in the areas of mathematics and physics [8].
- The commitment of the industry to collaborate in the process, to make students to identify the work using engineer projects.
- The responsibility that a professional should have with the development of their region and their country.

The new curriculum of the electronic engineering program has 160 credits, 53 courses, showing a significant reduction in both items compared with the current curriculum. Engineering education in first semester begins without interruptions and with high integration of interdisciplinary contents.

In this sense, working with other departments has been permanent and enriching. The CDIO group currently houses faculty from the departments of physics, mathematics, philosophy, theology, political science, history and the Group of University Social project (PROSOFI).

During the fourth year students have the option of choosing an emphasis of three potential areas; the offer for the integration of knowledge was reduced. Each emphasis has 33 credits, opposed to 9 credits of the current program. Those emphases have disciplinary components and skills related with the construction of product, process and system, integrating theology and philosophy issues. The culmination of the emphasis and the program is represented by a great project, which consists in a single problem to be solved by the entire cohort and by all the emphasis.

Figure 3 shows the new curriculum.

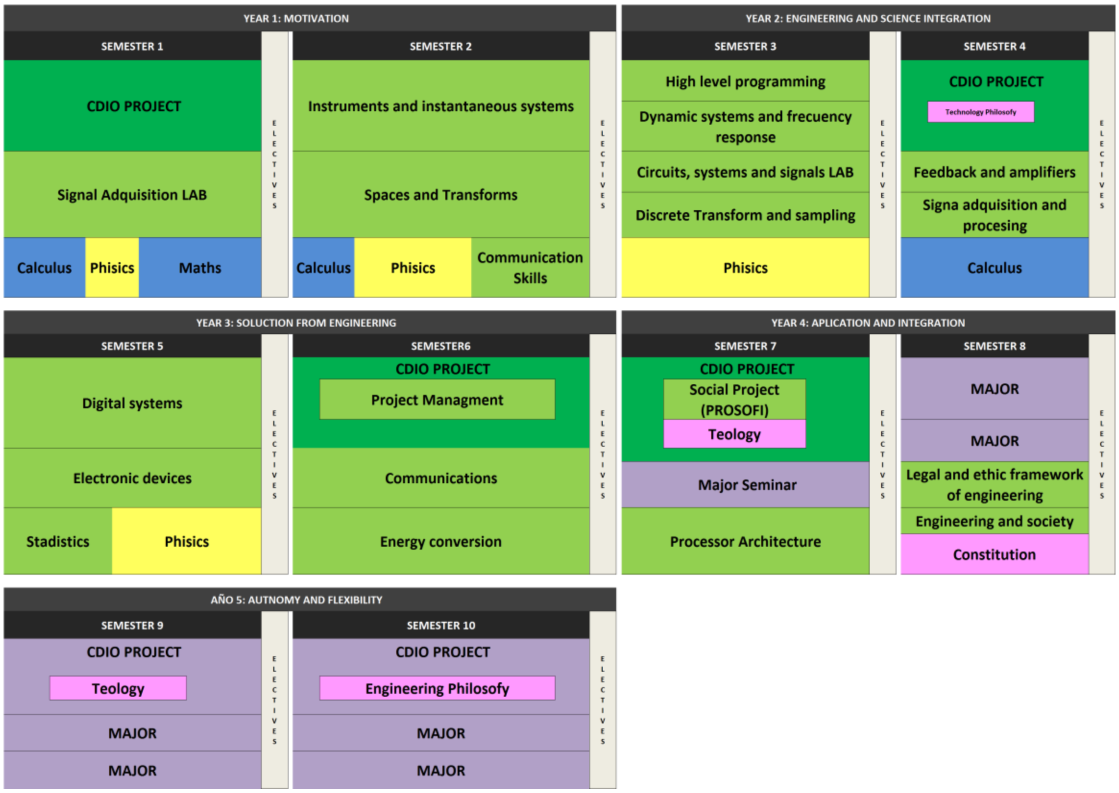

Figure 3. New Electronic Engineer Curricular Structure.

VALIDATION WITH EXTERNAL STAKEHOLDERS

At the same time that we develop the curriculum structuring was made evident the importance of industry and graduates point of view. For this purpose we conducted several interviews with executives from leading companies that hire our engineers; we conducted two focus groups with graduates. The objectives of these activities were the following:

- Determine what is the graduate profile perceived by the industry, establishing which are their strengths and weaknesses.
- According to the projection of different companies, what will be the occupational horizon for electronic engineering in Colombia in 10 years?
- From these projections which are the skills and competencies that graduate of electronics engineering must have.
- Establish a link between industry and the University.
- Invite industry and alumni to be part of our educational proposal in order to provide students real scenery, close to the professional practice.

Individual and group interviews were very productive, because they fed the process significantly. Below are some of the conclusions that we want to highlight in this context.

Regarding the profile of graduate students, we could demonstrate significant differences depending on the promotion to which belonged the graduate. In older generations, we can recognize features of arduous workers, learning skills, disciplinary proficiency and good attitude about the challenges. In younger generations these features are a little blurred, but it seems to be part of a widespread movement; industry cannot distinguish clearly the University from were those engineers proceed.

A constant that runs through the times is the sense of responsibility of the alumni from Universidad Javeriana; this characteristic makes our professional stand out against the others. Other attitudes that the interviewees highlighted were the ability to work in team and be open to changes. Interviewees mentioned disadvantages like lack of creativity and ingenuity, some empty discipline, depending on the area, poor communication skills and administrative skills. For graduates, there is a significant disconnect between academia and the world of work; they manifest that University does not prepare them for the challenges that they will face and the real demands from the Colombian work market.

The ten years projection raised various scenarios, according to the area of interest of each interviewee. In conclusion, we can say that for electronic engineering there are many possibilities in the future which refers to the significant and rapid advancement of technologies, particularly wireless communications, nanotechnology, controls, which new age is demanding. Discussion on this subject is what technological development will be created and designed in Colombia? Several of those interviewed are skeptical; for them new creations or new designs are not carried out in our country, because we are adapting technology that already exists. Although under this perspective the scenario is restricted, possibilities for development and action are still wide-ranging, for example, the interviewees mentioned the development of custom applications according to the changing needs of today's world, the possibility of creative integrations where the technology can be further, and the proposal and development of projects that may be happening in different places of the world, leading to a global view of needs and solutions.

It draws our attention as the concept of local and overall things are present in the industry and graduates image; in this sense, we need to be aligned with global trends, but it is important to take into account local contexts for customized solutions. This projection requires specific demands to the education of our engineers. In order to be at the height of these possible future scenarios, graduates must have greater mastery of languages and an open attitude to different cultures and forms of work. They must have great ability to lead projects working in interdisciplinary teams, which may be located in different places of the world. It is necessary that the Academy approaches them progressively to the real context so they can know how they will be facing that world and will recognize the tools in these new environments to be proactive and creative. The majority of the interviewees were agreed that it was not necessary to saturate students with a vast amount of disciplinary knowledge; it is necessary they have strong disciplinary fundamentals and that they understand how could reach and integrate new knowledge, keeping updated this one in their areas. Alumni highlight the importance of business skills to sell ideas, to arise as an engineer, to support a project, to win a tender, etc.

These findings have an obvious affinity with the CDIO initiative and the proposal we are working with. In the majority of cases it was very pleasing to observe how demands and dreams from company's managers and graduates, fit perfectly with what we want as University in a close future. When we inquire about the desire to participate in the training process, in all the interviews we receive positive answers. The managers of companies wanted to be in contact with the students and supporting them with their experience. Graduates on the other hand expressed that they would like to return to the University in order to share their experience. We can conclude that the validation process with graduates and industry was positive. Our education proposal is consistent with demands from the industry and the work market related with the near future. Skills chosen, selected emphasis and the way we are organizing the curriculum, respond to real needs. We can say that the line of work was validated, and in this way we feedback positively our internal process.

Finally, work with schools is being very important. High schools are stakeholders which oriented the training of our students before they enter university. This work has become a strategy for the promotion of engineering as an alternative vocation. During reflection of program a group of 5 high quality schools was integrated to share the CDIO initiative and to promote science and technology through its philosophy. The main objective of strengthening the relationship with schools is to start educating the profile of an engineer, even from the early stages of formation. Another goal is to share experiences with teachers from schools and the University, creating a continuous and effective synergy.

CONCLUSIONS

Revision of the electronic engineering curriculum let us to structure a curriculum-based CDIO Initiative with focus on promoting the development of capabilities to conceive-design-implement-operate products, processes and complex systems with added value and teamwork-based. The project was developed consistent with the CDIO initiative, and included the participation of managers, teachers and electronic engineering students as well as an external group composed by industry, graduates and schools. Workshops with faculty allowed the approach to issues related with the future of education in electronic engineering and the meaning of the construction of product, process or system. The outcome of these workshops was the basis for the definition of skills and competencies necessaries for engineering professional practice. Faculty teamwork allowed us to reach conclusions about the fundamental task of the engineer, this is, the cycle of product construction, and the relevance of disciplinary knowledge, the capacity of innovation, and the development of skills to communicate ideas and to manage projects, all framed in a clear social and environmental commitment.

Stakeholders contributed significantly in the development of graduate’s profile and to make clear the importance of local and global knowledge in an educational projection, i.e. achieve a clear connection with global trends, taking into account local contexts for achieving relevant solutions. Participation of schools as well as providing the definition of aspects about the formation of our students became a useful strategy for engineering promotion as an alternative vocational program. For us, it is possible to affirm that two aspects contributed to the achievement of the objectives we set ourselves: the Group of 14 teachers who, by consensus, reached agreements on the adaptation of the CDIO syllabus, and the support provided by the team of professionals of the CDIO initiative at different stages of the process. Finally it is important to note that the curriculum revision within the framework of the CDIO initiative made it possible to integrate to the process departments such as physics, mathematics, philosophy, theology, political science, history and the Group of University Social project (PROSOFI).

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