

CDIO LEARNING WORKSPACES IN THE PONTIFICIA UNIVERSIDAD JAVERIANA.

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ABSTRACT

The CDIO framework as context for curriculum design implies among other things, rethink the workspace structure, to strengthen the processes involved in learning personal, interpersonal, and products, processes and systems construction skills. The Faculty of engineering of the Pontificia Universidad Javeriana in the process of curricular reflection of its four undergraduate programs (Civil, electronics, Industrial Engineering and software) has undertaken the challenge of conceive, design, implement and operate a complex of spaces inspired by the learning of engineering, which has as main characteristics being motivating, inclusive, flexible and creative. Criteria for the workspaces conception and design are generated from the skills of the CDIO Syllabus which were integrated into the programs and the curriculum structure based on design experiences. The total construction of the 3500 m² complex of spaces is projected to the 2016 and will count with the support of Hewlett Packard, in order to be a Center for teaching and learning in engineering model for Latin America. The present work shows the specification of 6 types of workspaces that support the CDIO standards and the integration of skills.

KEYWORDS

CDIO initiative, learning spaces, curriculum, teaching engineering, engineering design.

CDIO INITIATIVE ADOPTION

The CDIO initiative is the base of the reflection of the education in engineering at Pontificia Universidad Javeriana, under the principle: "training in engineering should provide students with an education that emphasizes the fundamentals of engineering framed in the context of conceive, design, implement and operate (CDIO) systems and products for the real world" [1]. For this purpose, the institution and its resources should facilitate the development of a curriculum organized around the mutual support between disciplines, a curriculum interlaced with learning experiences related to personal and interpersonal skills and products, processes and systems building abilities. Thus, students receive an education in the framework of experiences of design, implementation and active learning; these activities must take place in modern learning workspaces that promote inclusion, flexibility and creativity [2]. The CDIO concept tends to motivating environments that aligned with the demands of the context allow these experiences and activities bring students to the development skills and values that will enable them as future engineers and in this way deliver solutions to the needs of the society in which they are framed.

CDIO STANDARDS

The Pontifical Universidad Javeriana has adopted the twelve standards or CDIO principles as points of reference for curricular reflection of its 4 programs [2]. This reflection will provide a framework for continuous improvement of the school of engineering. In particular the following standards are highlighted because they guided the conception and design of the new CDIO spaces, adaptation of other spaces and better use of the existing infrastructure:

Standard 3. Integrated curriculum

This standard refers to a curriculum designed from disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and skills of building products, processes or systems.

Standard 5. Experiences of design and implementation

This standard refers to a curriculum that includes experiences of design and implementation, containing entry level and advanced level.

Standard 6. Workspaces of engineering

This standard refers to engineering laboratories and workspaces to support and encourage practical learning from the construction of products, processes and systems, disciplinary knowledge and social learning.

Standard 7. Integrated learning experiences

This standard makes reference to experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and building products, processes and systems. These experiences include working methods based on experiences and active learning, based project learning, simulations, experiences of design and implementation, and case studies, among others.

Standard 9. Improvement in the competence of the teacher's skills and standard 10. Improvement in the teaching competence of teachers.

These last two standards (9 and 10) involve facilities to improve teacher's personal and interpersonal competences, abilities of construction of products, processes, and systems, and providing learning experiences based on the use of methods of active learning based on experiences and projects; and in the assessment of the learning of students.

Characteristics of CDIO workspaces derived from standards

From the CDIO perspective, design and implementation of experiences involves a series of events which leads to the learning through the development of a product, process or system. These experiences of design and implementation should add realism to the curriculum [3], illustrate the relationships between the different disciplines of engineering, encourage the creative abilities of students, provide successful activities in engineering, strengthen the self-confidence and motivate and entertain students. Therefore the curriculum should include basic and advanced experiences of design and implementation [2]. For the first, experiences must be included as early as possible in the program, during the first or second semester, when students are faced with raising solutions structured to engineering problems, learn to work as part of a team and learn to communicate their progress and results. The latter will be including during the program, offering opportunities to address the needs of the real world, to analyze, design, build,

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test and even operate engineering systems with increasingly higher levels of sophistication. In some cases experiences require teams of up to 12 students, higher levels of training, even graduate students who have faced research projects or industry professionals, cooperating with the solutions to real world problems, including technical challenges in different phases of the project, up to the integration and testing, verification and validation.

The development of these experiences can be more complex than the development of courses with traditional teaching methods. On the other hand, the planning and organization of these new types of experiences require consideration of several factors, such as the selection of relevant projects and the management of resources [4], in which the synergistic combination of appropriate work spaces and appropriate teachers support plays a very important role. Therefore, provide students with successful design and implementation experiences, requires a learning environment with adequate spaces, equipment, and tools. These facilities have been called workspaces, to suggest its link with the development of creative engineering and distinguish them from the laboratories which are areas that are traditionally used for scientific research and experimentation. Then, these areas are multimodal learning environments that support the conception, design, implementation and operation of processes to solve simple and complex problems, in individual and group teams [5]. These spaces must provide an infrastructure that supports active learning strategies and interdisciplinary collaborative practice. Figure 1 summarizes the main features of the CDIO workspaces.



Figure 1. CDIO Workspaces Characteristics

Spaces are articulated with the technology and design of these spaces or a remodeling must be inspired by the needs of the curriculum, in this sense, spaces, tools, and the training model are elements that make up a global structure [6]. This structure in the engineering school of the Pontificia Universidad Javeriana arises as a Teaching and Learning Center, which will support

the CDIO standards related to the professional development of teaching staff and will motivate research in education at the school of engineering. Research is a strategy of evaluation of programs in pursuit of continuous improvement. Figure 2 shows the model of the Teaching and Learning Center.



Figure 2. General model for the Teaching and Learning Center in Pontificia Universidad Javeriana

WORKSPACES GENERAL CONCEPTION IN THE SCHOOL OF ENGINEERING

The context of the education of engineering at Pontifical Universidad Javeriana promotes that students conceive, design, implement and operate products, process and systems, therefore they have to be immersed in work areas that are organized around C, D, I, and O. From this perspective, it is clear that the organization of the space can be used to point out the importance of context to the students and strengthen its education and training [4]. Consequently, the areas of work are a key element of the CDIO programs strategy and these workspaces and other learning environments that support hands-on learning are important resources for the development of skills in design, construction and testing of products, processes and systems.

Workspaces mentioned above, central theme of the CDIO standard 6, must include traditional learning spaces, such as classrooms, conference rooms and meeting rooms, as well as engineering spaces, designed to promote hands-on learning in such a way that students directly get involved in their own learning development, count with opportunities for social learning, and get training in values and interpersonal relationships [7]. Therefore, these spaces must include access to software and modern engineering tools, so that students have the opportunity to develop knowledge, skills, competences and attitudes that support the construction of products, processes and systems, skills that are better developed in spaces of work focused on students, easy to use, accessible and interactive [8]. On the other hand, these learning spaces must motivate teamwork and the formation of engineering communities, in stimulating environments that reinforce the motivations of students and teachers and improve the interaction between the actors in the process. The previous perspective contrasts with conventional laboratories with a focus on discipline contents and in which students take a more passive role; i.e., they tend to be focused on demonstrations and they do not encourage students towards the conception, design or building of a community of students, professors and researchers.

As part of exploration work, assimilation and reflection of this initiative and its projection to the formation of professionals in engineering, different types of workspaces have been proposed:

Open spaces oriented to work in interdisciplinary teams, allowing students to imagine new systems in order to promote their conceptual development and their reflection about new systems, as well as the use of resources that include boards (digital or acrylics), access to online resources, bibliographic information and laboratory equipment [9]. Also, spaces that support the new paradigms of the collaborative design teams and infrastructure are suitable for simulation, design, computer assisted manufacture, development and implementation of prototypes, easier access to video conferencing, databases, testing, verification and validation of the developed prototypes. In this way spaces for socialization, personal study, group work and discussion will be provided, and include areas of cafeteria, with opportunities for recreation and relaxation and students of different races, programs, and projects converge [8]. All these spaces, if possible, should be connected and, more importantly, they must be close to each other, in order to strengthen its ideological link: CDIO. They should reflect the research in engineering and the development of projects within the different departments or programs, as well as among themselves.

The present work shows the specification of 6 types of workspaces that support the CDIO standards and integration of competencies. In the first place has been conceived the "Free Plaza" for individual and collective work that support the processes of autonomous work and work outside the classroom. Secondly the "Project Plaza" sites that will host the development of multidisciplinary CDIO projects and which will encourage the creation of a community of engineering are proposed. A third type of space is the "Studio", workplace suitable for simulation and communication, which has technology as a mediator of the process of learning. In fourth place are "Combined Workspaces", comprising a traditional classroom and lab in a same place; this spaces support the concept of instant theoretical and practical learning. The fifth is the "Show Room" that will give the appropriate infrastructure for teleconferencing and remote classes, which are common in the School of engineering. Last space "Faculty Plaza" is dedicated to the conception, design, implementation and operation of courses and integrating projects; there are spaces dedicated to the teachers and the education planning, spaces which could contribute to built an academic community which design teaching learning strategies. This faculty plaza has the same facilities and infrastructure that the spaces dedicated to learning. In general, the proposed spaces will facilitate the group work, social interaction, and the consolidation of a community of engineering that integrates teaching and learning in a building.

COMBINED BASIC WORKSPACES

These workspaces use basic technology resources to conceive, imagine and create new systems. In these spaces, through an active teaching, each student is supported during their first semesters in order to help them to get understanding of customer needs and to develop basic concepts through hands-on activities. These spaces will support the interaction between groups and subjects through oral and written communication processes and using listening and reflection strategies. These areas are conceived in order to strengthen the experimentation, curiosity, and the discovering of knowledge as well as the development of critical thinking through discussions in peer groups. These are seen as open and flexible areas, with differentiated spaces for groups of 30 students, which have six-sided tables, laboratory equipment and computers. In these areas students begin their CDIO cycle with the "C" (conceiving). The name *combined spaces* was given because these areas mix a traditional classroom with a laboratory classroom, so the theoretical concepts can be applied instantly.

COMBINED ADVANCED WORKSPACES

They are workplaces with specialized and advanced resources which will be conducted using teaching with active methodologies and learning strategies based on problems and projects which give the option to conceive, design, implement, and verify the proposed developments to deal with a problem of industrial context that bring real needs of the external world.

In these activities, team, collaborative and interdisciplinary work, emphasizing the communicational skills and training in social values are relevant. Similar to the basic combined spaces, these places will be open, flexible, areas for 30 students, equipped with computers, and with access to specialized measurement equipment. C, D, and I are works in these areas. Figure 3 shows a pre-design of the combined spaces and a summary of characteristics and competencies of the CDIO Syllabus from which they were conceived.

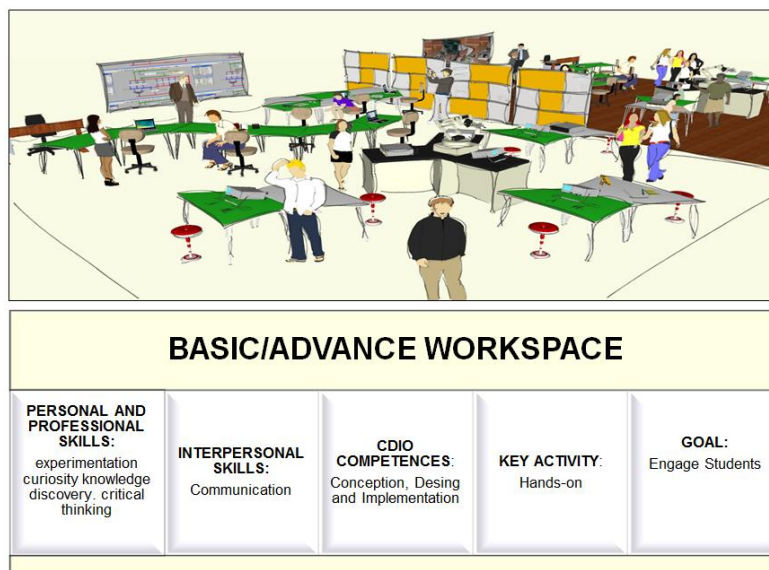


Figure 3. Basic and Advanced Combined workspaces.

SIMULATION STUDIOS

They are spaces of work focused on design skills including the phases of simulation, verification and validation. They are flexible spaces to accommodate groups of 30 students, in hexagonal tables, with computers and specialized software for design, simulation, and analysis (assisted computer design). In these spaces, students may be simulating their developments from the presentations or early theoretical reflections, involving C and D. The Studios are designed to strengthen the processes of reasoning, modeling, creative thinking and analysis with uncertainty. An additional factor is the possibility of working concepts of intellectual property emphasizing the values of ethics, integrity and responsibility. Electronic communication and argumentation skills will be essential in these spaces. Figure 4 shows a pre-design of the Simulation Studios and a summary of characteristics and competencies of the CDIO Syllabus from which they were conceived.

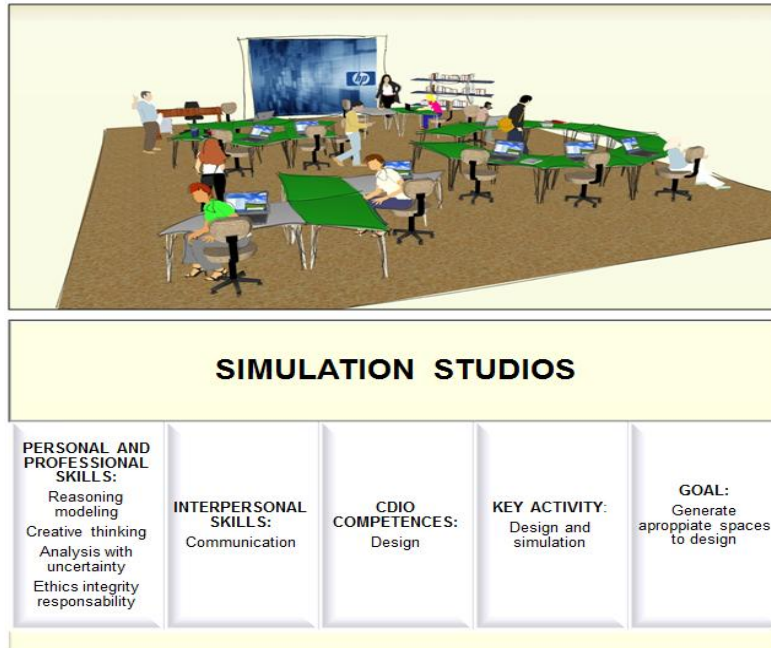


Figure 4. Simulation Studios.

FREE PLAZA

They are large spaces for free work, allowing students to conceive and design systems, share their progress with in peer groups, generate discussions and meetings. Typical equipment will be made up of computers with software of simulation and design, smart boards and internet access, recording and printing facilities. They are spaces of conception that encourage creative thinking and systemic thinking. They are conceived as social areas of independent work focused on the construction of academic communities of students. The Free Plaza includes coffee and entertainment areas, equipped with modern and comfortable furnishings. In these areas time of study of the students is developed, but also the time of social interaction. Figure 5 shows a pre-design of the Free Plaza and a summary of characteristics and competencies of the CDIO Syllabus from which they were conceived.

PROJECT PLAZA

Workspaces equipped with the necessary infrastructure for the development of CDIO projects; in this sense are broad areas in which students of the engineering program from all semesters, including postgraduate students, teachers and industry representatives, who integrate a community of engineering that is based on communication, teamwork and professional behavior. Project Plazas are equipped with computers and technology sufficient to the development of systems, processes and products in the four areas of focus: Electronics, systems, civil and industrial.



Figure 5. Free Plaza

The areas of work and equipment are assigned during projects; this responsibility favors the values of responsibility, integrity, ethics and autonomy. The conception of these spaces is routed to motivate and develop high levels of competence in problem solving, creative and critical thinking. In Projects Plaza students can demonstrate a real CDI cycle, before the operation. Figure 6 shows a pre-design of the squares Project and a summary of characteristics and competencies of the CDIO Syllabus from which were conceived.



Figure 6. Project Plaza

SHOWROOM

They are workspaces dedicated to face-to-face and remote lecture. These spaces are distinguished from a traditional classroom in videoconferencing and Internet access facilities. They are equipped with computer equipment for all students, cameras and wireless connectivity facilities. These spaces are based on work with the conception-related skills, because lectures are the first moment of conception, when the discipline and relevant technique information reaches every student. The design and infrastructure of the showroom tend to motivate communication in all its fields. Figure 7 shows a pre-design of the showroom and a summary of characteristics and competencies of the CDIO Syllabus from which they were conceived.

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Figure 7. Show Room

FACULTY PLAZA

These areas involve teachers in the entire CDIO process, supporting the conception, design and implementation of courses and learning activities. On the other hand strengthen curriculum planning processes and academic discussions among peers. They are areas similar to the Project Plaza, but dedicated to the teachers and to create an academic community. Equipped with appropriate technology and equipment, Faculty Plaza will allow teachers to innovate in their classes and conduct research in education through the collection of information evidencing that the competencies and knowledge have been achieved according to the profile established by the program. Figure 8 shows a pre-design of the faculty seats and a summary of characteristics and competencies of the CDIO Syllabus from which they were conceived.



Figure 8. Faculty Plaza

These workspaces contribute to build a community of engineering where teachers bring their knowledge, industry representatives share their problems, needs and challenges, and students take advantage from the possibility of integrate theory, disciplinary real problems and their own interests and knowledge. They can develop through this space not only disciplinary knowledge but also personal and interpersonal skills because they get conscious about the need to support their proposals as partners on equal conditions.

CONCLUSIONS

Incorporating the CDIO initiative to the engineering school of the Pontificia Universidad Javeriana is intended to improve the formation of engineers aware of their responsibility in the design of solutions for social relevant discipline problems. With this purpose we have led the review of the engineering curriculum and based on this review we guided the creation of learning environments in which the teaching experiences will contribute to foster the development of personal and interpersonal skills to support building products, processes and systems. Revision of curriculum and study plans lead to the incorporation of basic and advanced experiences about design and its implementation in engineering; through these experiences students learn to plan solutions in order to structure disciplinary problems, participate in teamwork and communicate their progress and results. We recognize that the experiences of design and implementation added realism to the curriculum and allow future engineers to identify relationships between different disciplines in their area. Likewise, the early confrontation with real problems contributes to student's development of creative skills, systemic thinking and critical thinking and strengthens their self-confidence as a professional in training.

Designing spaces using tools and the training model in which has been working the faculty will form the Teaching and Learning Center. This Center is a project of the school of engineering at the University, in which CDIO standards will be implemented, fostering professional development of the Faculty, motivating research in education and allowing programs to evaluate the continuous improvement of the school. Workspaces and learning environments are CDIO initiative strategies that will support hands-on learning for the development of skills in design, construction and testing of products, processes and systems. The six workspaces designed to support the CDIO standards implementation and integration of skills, will make possible the practical learning and work team. In the other hand, spaces earmarked for teachers and planning education will facilitate work group, social interaction, and the consolidation of a community of engineering. Activities proposed in the spaces of learning are based on team, collaborative and interdisciplinary work, and emphasize in communication skills and training in social values as well as promoting skills to conceive, design, implement, and verify alternatives to address engineering problems and to respond to real needs of the external world. Team, interdisciplinary and collaborative work fosters the development of communication skills, and the training in social values, fundamental aspects of the engineering training.

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