CDIO IMPLEMENTATION USING 24/7 WORKING SPACES

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ABSTRACT

This document discusses the adaptations, reforms, and challenges faced at the Electronics Lab at Universidad Javeriana, in Bogotá-Colombia to provide adequate logistic support to the implementation of the CDIO model to the undergraduate program in Electronics Engineering. These adaptations involved not only the use of spaces, electronic equipment, computers, and availability 24/7 for students and teachers, but also the contribution to students learning in individual and intragroup responsibility, and self-regulation. The paper highlights how a successful implementation of a CDIO curricula have been achieved through some changes in the furniture, spaces for study and workgroup, as well as greater integration of the students while they conduct their academic work.

KEYWORDS

Workspaces, Laboratories, Electronic Equipment, Standard 6.

INTRODUCTION

CDIO standard 6 involves workspaces and laboratories since they are fundamental elements for an appropriate CDIO implementation (CDIO. 2017). The School of Engineering at Pontificia Universidad Javeriana in Bogotá, Colombia, has implemented deep changes in the spaces, use and administration of the Electronics Lab to provide adequate service and logistic support to the new CDIO curriculum in the Electronics Engineering Undergraduate (EEU) program[1] (González et al. 2013). The Electronics Lab is a service unit in charge of providing infrastructure, equipment and logistic support to academic activities offered by the Electronics Department.

The current CDIO curriculum, reform of the EEU program, enacted great challenges that needed to be addressed without increasing the areas and workspaces nor the number of staff members at the Electronics Lab. The CDIO model implies a considerable increase of the experimental and project component of the different subjects within the curricula, which in turn increased the number of lab users. Such changes directly impact the resource management available at the Lab for classes and research purposes (Sun, Wen, and Guo 2013).

The policies implemented to address the new requirements of the EEU program are the result of an ongoing strategic planning process which considered the new syllabuses, past experiences reported in the literature (Young et al. 2005), recommendations from teachers, and especially, self-report surveys answered by the students.

This document describes the adaptations, reforms, challenges and projections currently addressed by the Electronics Lab to give the adequate support to the CDIO implementation. These adaptations involved not only the use of space, electronic measurement equipment,

[1] For clarity purposes, EEU can be understood as a five-year bachelor degree in Electrical Engineering.

computers, and software, available 24/7 for students and teachers, but also the contribution to students learning in individual and intragroup responsibility, independence, practical work, safety rules, punctuality, solidarity, and sense of community. This document also shows how through those changes, group work has been achieved, as well as greater integration of the students while they conducted their work.

Such contributions have been achieved through various models of electronic equipment loan to students, such as equipment assigned to work groups for the class time (2 to 3 hours) and equipment assigned to work groups during the entire academic term (16 weeks, 24/7). Also, there are equipment kits available 24/7 for free use which are self-managed by the students. Such freely use and availability of the equipment is a big difference concerning the equipment loan management policies applied in other universities.

The following section shows a general description of the electronics lab and its infrastructure. Physical infrastructure and number of staff have barely changed since the construction of the engineering building in 1996.

ELECTRONICS LABORATORY

As mentioned, the Electronics Lab is a service unit in charge of providing infrastructure, equipment, and logistic support to several academic activities such as teaching, learning and research. The Lab is open 24/7 all the year around, except during the winter break (three weeks from the middle of December to the first week in January).

In particular, the Electronics lab offers services of workspace assignation, lending of electronic equipment and components, technical advisory, lab experiments design and testing, and short capacitation courses. Student users typically belong to EE, Computer Science, and Musical undergraduate programs, as well as Electronics and Bioengineering Master, and Engineering Ph.D. graduate programs. Moreover, the Electronics Lab provides services of technical support such as printed circuit board (PCB) design, prototyping and high complexity soldering, workspace assignation and personnel hiring for the different projects and research groups ascribed to the Electronics Department. In addition, the Electronics Lab is in charge of acquisition, maintenance, and inventory management of all the electronic equipment belonging to the electronics Department.

Currently, there are ten staff members at the Lab assigned to different roles:

- The Electronics Lab manager in charge of directing and coordinating all the actions towards the correct functioning of the unit, usually a role occupied by a faculty professor.
- One administrative assistant in charge of the purchase processes and administrative support.
- Three storehouse clerks, in charge of user attention, lending of equipment and components, workspace assignment, class logistics, storage and inventory management.
- Four Lab technicians in charge of maintenance of electronic equipment, computers, servers and software licensing, technical support, short capacitation courses, lab experiments design and test and other special services, such as 3D printing, PCB prototyping, and soldering.
- One system administrator in charge of managing, updating and feeding the online platform used for inventory and lending management.

PHYSICAL INFRASTRUCTURE

Currently, the Electronics Lab has an area of approximately 1,200 m^2, covering two floors at the Engineering building, distributed as follows:

- Eight general purpose workspaces with a capacity of a maximum of 15 students or five teams of three students. These workspaces are used by classes with a practical component or for freely work by any student during off-classes. Figure 1 depicts a typical general-purpose workspace during a class.

Figure 1. A general purpose workspace during a class.

- Ten workspaces used by students developing their senior capstone project or their master and doctoral thesis. It is worth mentioning that such workspaces are grouped by topic, hence there could be undergraduate, M.Sc. and Ph.D. students in the same room.
- Six special purpose laboratories covering the areas of automatic control, process control, power electronics, telecommunication networks, biomechanics, and robotics. These laboratories are used mainly to cover the practical component of those related subjects but also are used by some students in their senior capstone projects or thesis that require equipment placed inside these laboratories.
- Three classrooms with a capacity of 24 students, equipped with mobile tables and laptops loaded with specialized software such as circuit simulation, electronic design, electromagnetic design, and signal processing software, Figure 2 shows a picture of such workspaces.

Figure 2. Classroom equipped with laptops

- Three large open areas for group study with movable tables and easy access to floating electric sockets, as shown in Figure 3.

Figure 3. Group Study Areas

Although the areas and distribution seem to be enough to handle an Electronics Engineering program, the School of Electronics has kept the same amount of spaces for the past 20 years. However, the implementation of CDIO modified the instructional models, hence increasing the laboratory components in the majority of the courses within the curriculum. Therefore, the academic services and policies provided by the Electronics Lab have been updated to offer a high degree of flexibility for the users (i.e., students and teachers) and faster response to requirements while keeping equipment and resources in the best conditions.

LABORATORY POLICIES FOR DIFFERENT INSTRUCTIONAL MODELS

As mentioned, the Electronics Lab provides services to the EEU, Computer Science and Musical Studies, and to the graduate programs of Master in Electronics, Master in Bioengineering and the Ph.D. program. Nonetheless, the largest number of users belong to the EEU which has experienced a deep and extensive curricula re-engineering as a result of the adoption of the CDIO principles. This reform sets a new number of courses launched in the first term of 2016. Although the CDIO academic program is still reaching the sophomore year (4th semester), several pilots of the courses have been conducted, tested and refined in subjects over the junior year (i.e., 5th to 6th of the 10-semesters program)

The CDIO model proposes that the different courses offer learning experiences to the students with practical and lab components, e.g., experiments in laboratory and practical engineering projects. The new CDIO EEU program exposes the students to the lab and electronic equipment since their first week at the university. This situation implies an increment on the number of users as well as the number of courses that require the academic services offered by the Lab. Figure 4 presents the number of users and courses since 2013. As shown, the number of users of the Lab remained relatively constant before 2016 but they have been greatly increased since the launch of the CDIO program in that year. From the Lab´s perspective, users are accounted as individuals enrolled in a course which requires academic services from the Lab, e.g., a student that is enrolled in one practical course and another course with a laboratory component, is counted as two different users. A similar situation occurs with the number of courses since they are accounted according to the number of workspaces required, e.g., a course of 24 students that has two different laboratory sessions and requires two workspaces for 12 students each, is counted as two courses. Worth noting that despite these increases the Electronics Lab has not received a major increase in funding, therefore the necessity of reviewing and modifying the lab policies to account for the new requirements driven by the increase in users and courses.

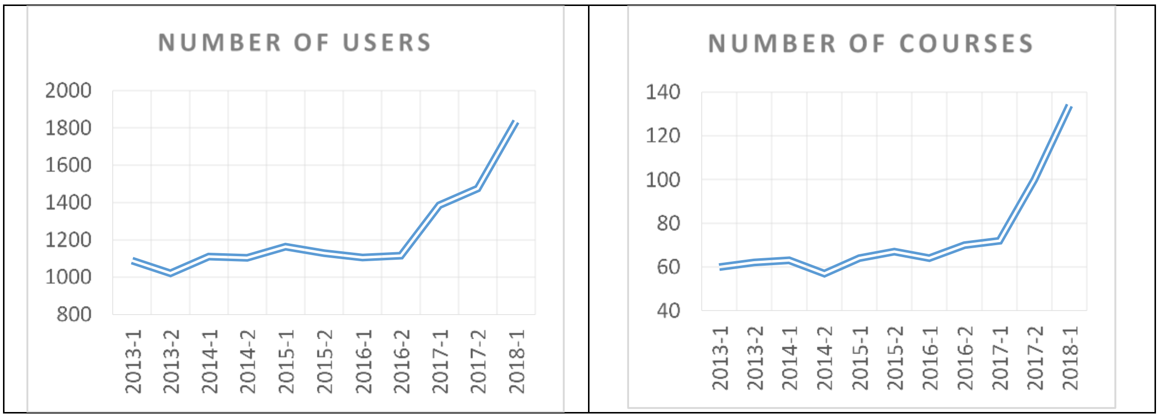

Figure 4. Number of users and courses serviced by the Electronics Lab

The courses of the EEU are offered using four different instructional models, which in turn determines the way that the Electronics Lab fulfill their particular requirements. The first instructional model is the traditional-teaching courses (typically belonging to the previous curriculum). Those courses are taught in classrooms along the University campus and are not typically lab users. Currently, those courses represent about 20% of the total of courses offered by the Electronics Department.

A second instructional model is composed by courses that are mostly theoretical, but the evaluation is performed using a project-based approach. Students in these courses must implement one or several projects during the semester. This model is used in courses such as Embedded Systems Design, Digital Systems Design, First Year Integrated CDIO Project, and Applications of Internet of Things. Those projects are developed in groups of two or three students. In this case, the Electronics Lab provides both development boards and a locker to store their materials to each group of students for the entire semester. Additional equipment must be solicited online and, depending on its availability, lent to students with no requirement of time in advance. Students can work on their projects using any of the eight general purpose workspaces during time frames where classes are not being taught.

The third model corresponds to those courses with a practical component that is used to reinforce or to clarify concepts taught in class. This model is used in subjects such as Fundamentals of Electric Circuits, Analog Electronics, Electronic Devices, Non-Linear Electronics, Control Theory, Dynamical Systems, Signal Processing Laboratory, and Electronics Instruments and Measurements. Each practical session is described using a laboratory guide where not only the experimental procedure is discussed but also all the equipment and electronic components required are stated. In this case, the Electronics Lab depot clerks have an estimated schedule of all the laboratory sessions at the beginning of the semester. Unforeseen situations may vary the schedule; hence the Electronics Lab is in charge to confirm all practical sessions within a week in advance. The day of the practical session, the depot clerks are in charge of organizing all the required equipment and electronic components, and to transport such materials to the correspondent workspace. At the beginning of the semester it is desirable to program similar practical sessions consecutively in one classroom, so it is possible to organize the same equipment set for a whole day and located it in one particular workspace. Nevertheless, this is not always the case. Thus, the organization and transportation of equipment is a permanent task of the Lab. Neither students nor teachers have to make reservations for their practical sessions. The Lab is informed in advance of the schedule and the organization of the equipment for a whole day of practical sessions is performed the day before. Lab technicians thoroughly review the experimental guides previously to the session, and if some updates are required, they informed the teachers in due time. Similarly, the technicians may also work together with teachers in the design of particular lab practices or experiments and participate in the elaboration of the written laboratory guides.

The fourth model includes those courses that follow a project-based approach. No theoretical sessions are taught because students reach such courses after completing previous modules that prepare them to develop the proposed projects. Courses in this category are Third and Fifth Year Integrated CDIO Project, Fundamentals of Electronic Design, Analog Design, Non-Linear Design and Senior Capstone Project. In all these cases, each group of students are assigned with a basic equipment set and correspondent probes for the whole semester. Each general purpose cubicle is equipped with shelves used by the students to store their assigned equipment as shown in Figure 5. Similar to the second model, those students that require additional equipment are entitled to make reservations upon availability any time and duration needed. Noteworthy, the Lab staff is not available 24/7, hence there are some time windows to claim the required equipment and components. The students in a group are co-responsible of the assigned equipment. Lending equipment to a group for the entire semester is intended to provide a positive impact in their individual and group responsibility, independence, practical work, safety rules, punctuality, solidarity, and sense of community.

Worth to mention, that the workspaces where the assigned equipment is stored (see Figure 1) are of free access for all students at all times, except when the classes and lab practices are scheduled. During this time, the use of workspaces is unrestricted and unsupervised. The students are not allowed to take or use assigned equipment belonging to other groups. Nevertheless, this policy is not hard enforced. On the contrary, students self-regulate their behavior in this regard. Even though there is a CCTV to cover all the Labs areas, only on rare occasions this system is used to find damaged or missing equipment. Students develop respect for their pairs and leave their assigned devices trusting their classmates and students from other semesters, even when the assigned equipment might overcome the prices of USD$10,000. The first week of classes, students are informed regarding house rules and safety norms. Due to the fact that they will be working without supervision most of the time, students are responsible for their safety as well as their classmates'. In case of equipment damage or malfunction, students are encouraged to present a report to the Lab personnel. Most cases are related to normal use and deterioration. Some damages are the result of misconducts or bad use, and in those cases, students must replace the damaged piece or part. The same level of self-regulation is observed at the PC rooms, where a set of laptops is available at all times without safety attachments to them. Students are not allowed to take the laptops outside the classrooms, but similarly to the case of the equipment, the policy is not hard enforced. Students take responsibility for the caring and good shape of laptops.

Figure 5. Shelves located inside the general purpose cubicles used by the students to store their assigned equipment for the whole semester term.

Finally, the Electronics Lab offers several additional services to all the users. First of all, the Lab is equipped with a set of 3D printers managed by the Lab technicians. 3D printing is a free service for the students and is used for prototyping and final details for the projects in all the subjects. Second, the Lab offers PCB prototyping, soldering paste delivery and high complexity soldering. PCB prototyping and soldering paste delivery are performed using computer-assisted machines for such tasks. In these cases, students must bring both a blank circuit board to be printed and the components to be placed.

The Electronics Lab is open 24/7 all the year around. Such policy does not mean that the clerks are available the entire night lending equipment. The Lab has disposed a set of work banks and probes available for unrestricted use at any time. The unrestricted equipment is located outside the classrooms in the hallway, and any student that needs one or several pieces of equipment is encouraged to use them for the time needed. Worth to mention, that the unrestricted equipment is enough to perform most of the measures required. Students put back the equipment on the respective shelves after finishing their work. Periodic preventive maintenance is performed on this equipment to calibrate it and maintain it in the best possible conditions. As the reader may notice, both, the unrestricted and assigned equipment, is stored on shelves outside the depot at the Lab. The assigned equipment is used only by the groups entitled to it. The unrestricted equipment must be correctly stored after use. These rules are informed at the beginning of the semester and enforced during the academic term. Students recognize the privileges given to them in this regard, and they have formed a culture of self-regulation and responsibility evidenced by the scarcity of reports of equipment damaged, missing o deteriorated. The unrestricted equipment, as well as the permanent assigned banks, were conceived as an experimental policy to address the increase of students' work requirements during nights and weekends. The policy became permanent after assessing its positive impact, mentioned by both, teachers and students, in surveys and the suggestion box.

ELECTRONICS LAB POLICIES

Since its origins, the Electronics lab has a sustained policy of renewing, maintain and increase the electronic equipment. Such policy was reinforced during the past five years, knowing the interest and posterior decision of adopting the CDIO initiative. Without an increase in budget (besides the inflation-based increase) the Electronics Lab has been making efforts to acquire sufficient amount of equipment to fulfill the increment of users and courses observed in Figure 4. The amount of the inventory in the Lab must fulfill those for unrestricted use, permanent loan, and laboratory practices. The Electronics Lab provided services to about 450 students daily from 6:30 a.m. to 8:00 p.m. and its facilities remain open during nights and weekends.

Lending equipment can be as restrictive as decided. As opposed to that, the policies implemented by the Lab have been oriented to offer a high degree of flexibility, with no restrictive times for reserving and soliciting equipment. Also, such policies aimed to reduce the response time to last minute requirements. In turn, a higher degree of flexibility in the lending process implies more complex management. To keep track of multiple reservations, lends, and inventory, the Electronics Lab decided to adopt an online service. In this case, the platform WebCheckout was selected to aid those processes. A systematized platform is mandatory to exert close control of the equipment that is currently outside the storage depot. Reservations are made online using computers or mobile devices. Lends are announced via e-mail and controlled using a public dashboard displayed on TV screens.

In turn, each equipment is monitored using the platform that allows to keep track of usage statistics, maintenance, and to set specific lending policies that restrict some equipment to a particular group of students. Statistics of usage are reviewed periodically to plan the purchases of those devices that are mostly reserved. Such statistics are also used to dispose of obsolete elements. One technician is assigned permanently to the management of the platform that includes setting-up the lending policies, feed the platform with new equipment (including its main characteristics, a photograph, a digital version of the manual, and information about availability). For internal use, additional information is included such as maintenance rounds and observations. An online system is the core support of an operation of such magnitude as the executed daily by the Electronics Lab.

CONCLUSIONS

An undergraduate program that incorporates the CDIO model supposes great efforts at the academic level and curriculum design. However, being that true, this is only a fraction of the challenges that an academic institution must address to provide the adequate infrastructure to support a program based on experimental approaches and projects. This paper has discussed how the management policies of the Electronics Lab of the Pontificia Universidad Javeriana, at Bogotá-Colombia, has been modified after the launch, in 2016, of a new CDIO-based undergraduate program in Electronics Engineering.

The new CDIO program in Electronics Engineering exposes the students to the lab at early stages in the process which in turn, implied an increment on about 60% of the number of users as well as an about 100% increase in the number of courses that require Lab services. The Electronics lab has addressed those requirements by changing policies aimed to increase the degree of flexibility in the lending process related to the four instructional models. In summary, such policies are equipment lent to individual groups during class schedule, laboratory equipment assignation during the entire academic semester to each group and equipment available 24/7 with self-management and self-regulation by the students. Knowing that the impact of policy changes in academic institutions could have a long delay, the latter two policies were implemented in 2012 and 2015 as a preparation for the expected increase in the number of users and courses.

With the model of work and loan of equipment that is held in the electronics lab, students must, in addition to fulfilling their academic obligations, implement their responsibility, both individually and collectively with solidarity and self-management. Although the institutional culture in the previous curriculum was also oriented to increase such values, the policy changes in response to the new requirements of the CDIO program reinforces such values. Otherwise, it will be highly difficult to accommodate to the new requirements without a substantial increase in funding and infrastructure.

The CDIO program was launched in 2016; the 2016 cohort is currently in the second year of five. Future challenges will be oriented to face more complex integrated projects such as the ones proposed for the third through fourth year of the program.

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