SPINNING NEW ENGINEERING STUDENTS' MINDS

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ABSTRACT

Freshmen of engineering curricula present, at their arrival, the lack of basic knowledge along with an unfocused degree of curiosity regarding specific and valuable or crucial engineering themes. The experience of building small projects in a relaxed context allows students to experience the satisfaction of surpassing small obstacles presented during these hands-on activities, increasing their self-confidence and willingness to learn more. Several studies have corroborated this and CDIO standard number 5 clearly refers the curriculum integration of two ore more design-implement actions, from basic to advanced levels, insisting upon the inclusion of design-implement experiences of simpler products and systems in first year curricula. Bologna reforms in teaching have posed new difficulties to engineering teaching/learning in Portugal. Bologna suggested change, some of it resulting in heavier weight of introductory engineering sciences, in first year curricula. This has led to an increased burdening of faculty staff and bigger obstacles to the implementation of teaching/learning experiences that differ from traditional methods. At ISEP, in the fall of 2009, following an IEEE-RWEP 2008 winning ISEP project proposal – "Vertical Axis Wind Turbine (VAWT) for Micro-Energy Generation: Spinning Students Minds" – the right conditions to establish a first experience in this context were gathered. This paper tries to share the experience of an IEEE-RWEP project-based learning first interaction with newly arrived students, looking for a CDIO framework, and the benefits, doubts and difficulties encountered. Attention was focused in grouping students from Electrical Engineering – Power Systems and Mechanical Engineering, promoting interpersonal skills and multidisciplinary work, attracting them into the experience but participating only if they whished to do so. It was also mandatory to obtain as much information as possible on all the enrolled students before, during and after the duration of the activities of the project, with appropriate surveys.

KEYWORDS

IEEE-RWEP, Basic Design-Implement Experiences, CDIO Framework, VAWT.

SPINNING STUDENTS' MINDS - MOTIVATION

Every year, we meet our newly arrived engineering students, with enthusiasm and eagerness to work as a team, one team that will reach a successful goal: to create confident and well prepared engineering professionals as well as (for some) good researchers in their areas of interest. In the last 10 years we have been watching an increasing lack of reciprocity in enthusiasm and willingness to work, as well as the unwillingness to put the necessary effort into it, on our students' part. Once they reach the university level, there appears to be a collective apathy – as in a "warrior's rest" after long battles. In the Portuguese public high school system, many changes have been applied in the last 2 decades. In the final years of our high school syllabus, teaching methods focus in an analytical style of thinking, although students are usually not invited to "think and reason" but rather to mimic problem solving and memorize information. Creativity has little or no room and dense syllabus take a heavy toll on students who "struggle" with impoverished reasoning to get to the next level – universities and polytechnic schools. The majority of students in the public system have difficulties escaping it and its consequences: "killing" curiosity and the joy of learning.

Bologna's reforms in Europe have brought new and demanding variables into this complex scenario. Although some engineering curricula knew how to grab the change [1], others, fairly lost in the process, had engaged the troublesome issue of preparing someone to be a full working engineer in just 3 years by means of a concentration of introductory engineering sciences, burdening the entire formation, with a particular emphasis in the first year of the curriculum. Bologna's paradigm also induced a change from Teacher-Centred to Student-Centred methodologies. The effort is gradually placed on the student's side since it is advocated that learning, is, before all, the ability to acquire the expected competences while displaying a certain degree of self-teaching and independent working and thinking. This, by itself, can transform the first year of their engineering degree into an overwhelming obstacle.

Taking the reflections produced by "The National Academy of Engineering of The National Academies", in 2005, the currently available models will destroy any chance or room of having imaginative students. Good, creative, idealistic and energetic students feel like misfits in engineering although being passionate about it. Many become discouraged when confronted with the formulaic, boring, individualistic endeavour that characterizes engineering education. They see little or no connection between engineering and the issues that do matter to them. Even amongst those that rationalize about the importance of engineering in addressing solutions for the benefit of humankind feel discouraged right from the start, suffocated in an apparently never ending set of overwhelming disconnected courses, distant from their sphere of interests and also from the notion and role of engineering in human life [2].

It is necessary to offer our students a starting point that can inspire their attitude in the (short) following 3 years, bringing out in them an active and dynamic attitude, driven by curiosity and willingness to learn more and better, whatever new subjects they may encounter. It is therefore crucial to have students become passionate about real, exciting team-based experiences right in their first year.

The CDIO framework explicitly invites the integration of these approaches in a structured, sensitive and well balanced manner (Figure1).

	Increasing Complexity ➔➔➔		
Activity	I-O	D-I-O	C-D-I-O
Structure	Structured		Unstructured
Solution	Known		Unknown
Team	Individual	Small Team	Large Team
Duration	Days	Weeks	Months

Figure 1. CDIO Standard 5 - Complexity Levels *versus* Experience Tagging [3]

Since contact time between teachers and students has changed, diminishing, it is important to know students outside the traditional classroom environment. The information one gathers from these contexts provides valuable guidance for future help to the students and helps the teaching/learning process to be more effective.

LOOKING FOR AN IDEA FOR A PROJECT TO USE AT ISEP

The CDIO European Meeting which took place in Porto during the days 25th to 26th October 2007, at ISEP, clearly set the basis for the need of promoting *design-build experiences*, in particular for first-year students. CDIO standards opened to us a new framework for the introduction of these approaches in our curricula.

We were looking for a project that could be of undisputed interest to a variety of students of different engineering options. It would have to be a subject "of the moment" but with some differences that would suggest the need for much future engineering research regarding some specific feature of the project. It would have to present a social and environmental benign application/impact for this is also crucial in the formation of a responsible engineering professional, not to mention a worthy human being.

The school head intensely promoted the CDIO framework, extensively sharing information, accepting incoming ideas and workgroups and enabling financial support to related activities. Unfortunately, there was little acceptance from our peers, who still perceive these changes as being of overwhelming proportions, demanding unwanted shifts in school calendars, objectives, strategies and *modus operandi*.

The 2008 IEEE-RWEP contest/call for projects information appeared precisely at this stage. We had our ideas and it was necessary to present a framework that could inspire a generous number of colleagues to cooperate in the project, without whom it would be almost impossible to handle the large number of new students we welcome at our school every year. There is a general feeling that the IEEE logo can be of great help in this sense, as we later confirmed.

IEEE-RWEP

What is IEEE-RWEP's aim? *The goal of the RWEP program is to provide university educators of electrical engineering (EE), computer engineering (CE), computer science (CS), biomedical engineering (BE) and electrical engineering technology (EET) world-wide with: a library of high-quality, tested, hands-on team-based society-focused projects for first-year students. These projects are designed to increase the recruitment, persistence to degree, and satisfaction of all students, and particularly women, in baccalaureate EE, CE, CS, BE and EET degree programs.*[3]

Therefore, in 2008 we applied for the IEEE-RWEP. The main criteria (relevance, quality and discovery) for double-blind evaluation intended a project that could [4]:

- "*address a problem whose solution benefits society*"
- Be "*presented in the context of a real-world, contemporary application*"
- Have the above "*connections made explicit in the proposed project*"
- Be "*described in a straightforward, organized, and complete manner*"
- Present "*description and methods accurate, clear, and concise*"
- Be "*tractable for first-year EE, CE, CS, and EET students*"
- Be "*appropriate for an international audience*"
- Be "*easily replicated at other institutions*"
- Have "*an appropriate scope to be done within two weeks of instruction*"
- "*result in student discovery of an underlying principle or concept in EE, CE, CS, or EET*"
- "*illustrate strategies and trade-offs that are important in the engineering problem-solving process*"

From a CDIO framework, Figure 2 summarizes the IEEE-RWEP project structure.

	IEEE - RWEP PROJECTS
Activity	I-O
Structure	Structured
Solution	Known
Team	Small Team
Duration	Weeks

Figure 2. Complexity Level of IEEE - RWEP regarding CDIO framework

In order to fulfil these objectives, an IEEE-WREP project has a set of documents that creates the right conditions for reproducibility of project worldwide. Table 2 presents the minimum core of documents asked.

Table 1
Required documents to backup an IEEE-RWEP Project

A background lecture (30-40 PowerPoint slides) that motivates and introduces the problem and provides the necessary technical background (for presentation to the students). The impact of the problem's solution on society must be demonstrated and illustrated in the context of a real-world, contemporary application.
A student project assignment (2-3 page PDF document) that recaps the problem and details the hands-on project to be conducted (for distribution to the students who would conduct the project). This assignment must detail what the students will do and what they will discover.
A faculty project description (3-5 page PDF document) that details the hands-on project (for distribution to the EE, CE, CS, and EET faculty who would use the project in class). This description must include a description of the resources needed to conduct the project and explicit directions on how to build/assemble the system (if applicable). This description must also include the necessary data, code, or other methods for executing the project. Finally, this description must explicitly describe the expected problems, strategies, trade-offs, and results.
A project report solution (3 page PDF document) that provides an example to the EE, CE, CS, and EET faculty of a successful, complete, student project report. The sections of the project report include: problem definition, methods, results, and conclusions. The report should include graphs and data (as appropriate), the observed trade-offs, the employed strategies, and what was discovered.
A summary lecture (20-30 PowerPoint slides) that reviews the problem, the methods for solving the problem, the trade-offs and strategies involved in the solution, and what was discovered (principles, concepts, etc.; this is for presentation to the students). The summary lecture should conclude with the reconsideration of the real-world application and its benefit to society.

IEEE-RWEP – Vertical Axis Wind Turbine (VAWT) for Micro-Energy Generation: Spinning Students Minds

The theme of renewable energy is a very appealing theme and young students are usually very curious on every new detail on this subject. Wind parks have a notorious presence in large country areas and in costal regions as off-shore structures. Nevertheless, using the built environment in cities to take advantage of its particular features and generate electrical power using wind, is still little exploited and studied. One important advantage of wind energy in the built environment, especially in larger cities, is the possibility to generate energy precisely where it is most needed, particularly in winter periods. The major difference would rely on the type of turbine we believe would do better in such a context: a Vertical Axis Wind Turbine. The concept could also be easily applied in remote locations to help communities in need to have access to some electrical energy.

This lead to the idea that was presented (Table 2). The project plans the construction of a vertical axis wind turbine as well as the design and construction of a small generator to be driven by it, preferably using common daily life materials.

Table 2
The idea for IEEE-RWEP Project

VERTICAL AXIS WIND TURBINE (VAWT) FOR MICRO-ENERGY GENERATION: SPINNING STUDENTS MINDS
Introduction and Impact: A growing energy demand along with environmental concerns has driven engineers into the search for alternative solutions in power generation based on renewable energy sources. Wind power usually needs large open land areas which can be a difficulty for heavily populated nations. In many nations attention is being given to distributed energy strategies and the promotion of energy production as closely as possible to consumers. Technology and social awareness are beginning to join efforts in order to bring green-power generation into modern cities that have a renewable potential still unexploited. But harnessing the wind in a city context is still far from reality. Winds in urban areas are of fast changing direction and have highly variable intensities. Vertical axis wind turbines are an attractive concept for energy production in these areas since they do not depend upon wind direction, they tolerate heavy winds, they can withstand gusts of wind, they are silent and, depending on the nature of the VAWT, they can be placed almost anywhere in a building or around it, to take the best advantage of air flow produced by the interaction of buildings and wind. The search for the best turbine design and generator configuration prepared for building installation in a low-cost/high efficiency philosophy, supported by a serious scientific study to aid development and design, is nowadays an imperative. Most designs have a cut-in wind speed of 4 to 5m/s. It is desirable to achieve lower cut-in speeds, improve rotor design, develop better materials for rotor structures and develop more efficient generators, all done within the adequate safety measures for such projects in a urban environment. *Hands-on-project: The students are invited to build a VAWT using mainly parts from junkyard and adapting adequate rotating electrical machines (PM motors, etc) in order to present a fully working wind generator prototype to be tested in an urban environment. The prototypes have to be sturdy and cheap. Any type of design from Savonius to Darrieus to other types of VAWT turbines is accepted as long as the system proves to be capable of starting on its own. This project will take place during the very first 15 days of first year engineering students and intends to captivate these students into an engineering mood on a cooperative work basis. Students will be coached (academic staff + seminars) during the first week and will have to conclude the building of the prototype, on their own, during the second week.* *This means a first contact with engineering science, pursuing creative approaches and increasing self confidence and curiosity in first year students. The fact that our students are eager to know more about renewable energy and are willing to devote time and effort into a social and environmental important issue has a positive impact in the way they will be learning and acquiring competences throughout their years at the University. It is our goal to help our students to Conceive, Design, Implement and Operate their projects while "starting to feel like engineers".*

We planned the two week intervention to meet CDIO standards, particularly standards 5, 7 and 8. The theme, from the technical and scientific point of view, is normally a novelty for first year students and embraces several engineering curricula students, allowing them to experience multidisciplinary and interpersonal dimensions. Figure 3 shows the main philosophy for the two weeks of work.

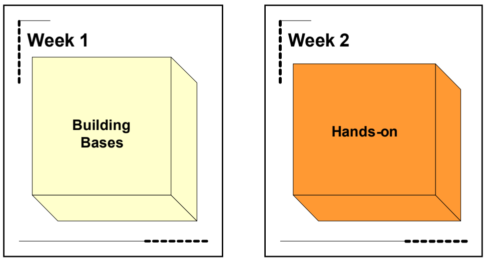


Figure 3: Two Week Block Defined for IEEE-RWEP

Building bases must go beyond technical and scientific knowledge necessary for project building. We clearly looked for effective teamwork and team operation. Scarce experience on teamwork and no knowledge of the other team members may be a serious drawback to the collaborative process and ultimately may affect the quality of the outcome. It is fundamental to introduce the principles of teamwork, essentially on collaboration aspects, team characteristics and task analysis. The groups should work together from *starting day* and a tutor is assigned to follow up groups.

For the “hands-on” week, we clearly wished that students could explore and test different possibilities of VAWT and even be creative enough to introduce changes to the established structure. Brainstorming between each group and their tutor will be fundamental all week long. Adjustment of the main steps and discussion of which materials to use and design strategies to follow should be explored. It was also expected that students can previously execute a realistic analysis, bearing in mind the contest and how the jury will test each prototype and evaluate it according to a number of items (VAWT startup; VAWT ease of spin; Aesthetic of the structure versus working condition; Generator output; Final cost). Such an “empathic” attitude should be encouraged.

Project reviewers wisely remembered us that used parts would not be adequate since this is a limitation to replicate the project in other institutions. As already stated we wanted to do some dynamic team grouping scheme but, although everyone agreed that teamwork is very important, we were advised not to be too concerned with this and that it would be enough to ask instructors to do team-building before the project starts. The generator construction had also to be removed from the proposal and replaced by a motor or generator easily acquired by anyone whishing to replicate the project. In the end, the accepted proposal referred to building the Savonius type turbine but coupled to an existing motor-as-generator.

Finally, the work was scheduled according to the following block diagrams depicted in Figure 4:

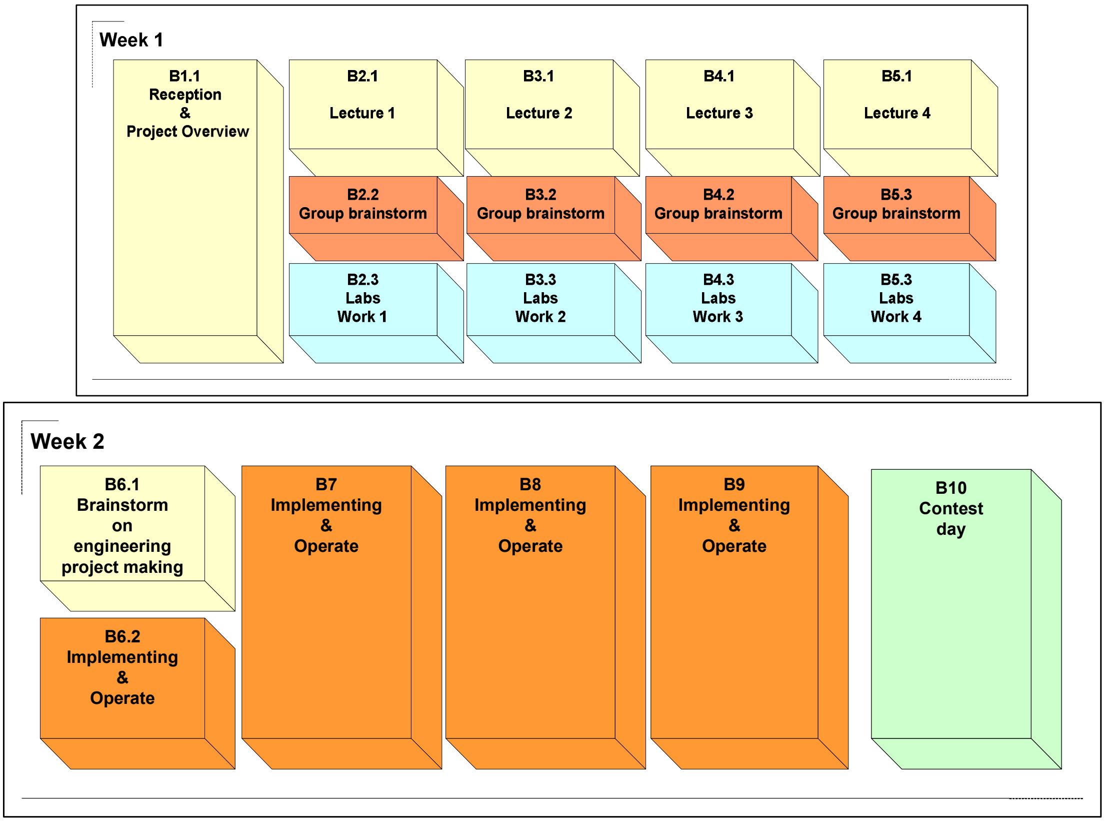


Figure 4: Schedule Defined for the Two weeks

The "Conceive – Design" dimension of the initial proposal had to be removed from the IEEE-RWEP project (to meet reviewers indications) since it would collide with the intentions of a perfectly structured project proposal meant to be replicated at other institutions. At this point, meeting standard 5 was reduced to the Implement and Operate stages of this standard.

USING THE IEEE-RWEP PROJECT AT ISEP

IEEE projects are meant to be used as an appetizing helping tool for learning in first year syllabus. This implies that some change to the curriculum is necessary to accommodate any new such tool (project). Reaction to change in engineering syllabus, to integrate these new approaches that privilege design and creativity over a more standard and rigid curriculum, have been proving difficult to do [3]. We believe that the best period to implement the project would be between the 2 semesters of the first year, due to the multidisciplinary nature of the project. It would also allow for the increase in the number of participants since it is easier to contact every possible participant.

Although the head of the school embodies the will to change, many departments still present doubts on whether or not it is feasible to do, since it was argued that this demands human and technical resources that are rather complex to guarantee. Ensuring the technical dimension of the problem is, nevertheless, simpler than certifying the human cooperation needed. Changing things is not easy, but the IEEE logo did help in motivating colleagues to cooperate.

In view of this, we decided to do some adaptations in order to implement the project with the freshmen at their arrival at ISEP (prior to the starting of classes). Again, the idea of a welcome project could mean important changes in their behaviour and way of thinking as students from this point onwards.

At ISEP we have every year about 500 new students divided into 9 different engineering curricula. Scalability is an important issue since this project demands the use of many and specific tools as well as space, not to mention the help of numerous members of our staff, if such a number (500) was to be considered. Some curricula would have students that would certainly be more prone to this particular project theme than others, due to the nature itself of the curriculum.

After a long discussion it was agreed that for scalability reasons and cooperation availability it would be better to try out the project in a smaller group. Two engineering curricula were selected: mechanical and electrical engineering - power systems for their natural correspondence of curriculum themes to the nature of the project. The universe of candidates was (roughly) of 40 power system students and 110 of mechanical engineering students. Out of these two curricula it would be difficult to have more than 40 students enrolling, as we would later discover, and we planned things for no more than 40 freshmen.

The next step was "how do we let the students know about the project?" ISEP is a state school of engineering. Our students are placed at ISEP through a national process, affecting every public school (polytechnic, university). Once students know where they are going to go study for the next years, they have to register at their school of destination and this normally occurs 15 days before the beginning of classes. At ISEP, students register online. We used contact information that students provide when enrolling and sent an SMS with the project info and reception morning schedule. We also managed direct contact with students by going to the Welcome Sessions organized by the Student Supporting Office. We presented the project at the end of the sessions of the 2 selected curricula. There were about 30 power system students and 40 mechanical students in their respective sessions. They were told that enrolling in the project was optional. Questions arose and answers were given but this scarce direct contact with the universe of potential candidates to the project didn't produce all the desired outcomes.

Since things had to occur prior to the beginning of classes, the 15 day period consecrated to the project in the IEEE-RWEP structure would no longer hold. Therefore it had to be "squeezed" into a week long set of activities & one first morning for presentation of basic information and the staff, the idea underlying the project, the events expected to occur (where, when, how…) and a final gathering around coffee, tea and cakes for a first "nice" acquaintance of everyone and, hopefully, a way to retain those students to do a hands-on project at their arrival in a school of engineering.

The project would, therefore, consist of a 1 week challenge, with introductory presentations on the subject in the first couple of days, (using the materials developed for the IEEE-RWEP project), the following days being devoted to building, testing and tuning the VAWT set. The final afternoon was reserved for the contest.

In the "first morning presentation" 30 students signed in. Later on, only 25 stayed with us (one third power system students and two thirds of mechanical engineering). Of the 5 students that did not continue, one got sick, one mentioned sudden family issues incompatible with the schedule for the week and, on the remaining 3, no information was available.

DETAILS AND PHYLOSOPHY OF THE IMPLEMENTATION OF THE PROJECT AT ISEP

Figure 5 presents the implementation calendar of the adapted IEEE RWEP project at ISEP during September 2009. The reduction of the project duration lead to some trade-offs. Lecture and Labs were more intensive - only two days - with double sessions. The hands-on was also reduced but more "coaching" from teachers would be necessary and special attention to group "formation" and task division were encouraged on the start-up phase.

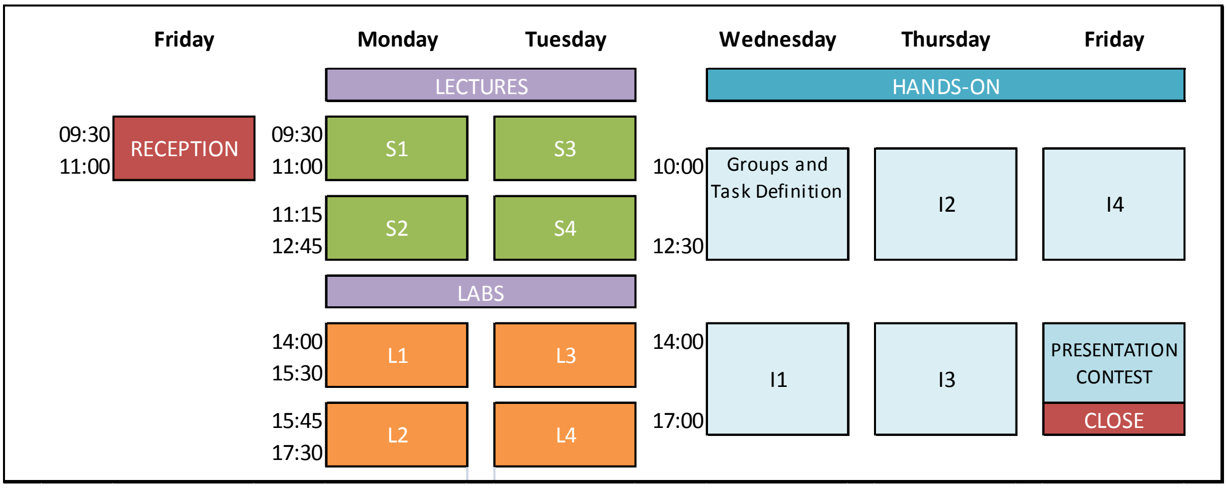


Figure 5: Project Calendar

The Reception morning corresponds to IEEE-RWEP Background Lecture. In this session, a first survey was performed to get some information on the students' background and motivation for engineering. We also wanted, amongst other questions, their opinion on how they thought that a project based approach to a technical subject could be of interest to them.

Giving the basic information on VAWT's and generators

Lecture Sections

These sessions should be in a documentary mode, presenting formulae, of course, but not as in conventional classes. The themes of these sessions were:

S1 Basics on wind. Wind energy conversion
S2 How to harness the wind? Wind turbine technology
S3 Small VAWTs: practical issues
S4 Electricity and electrical generation

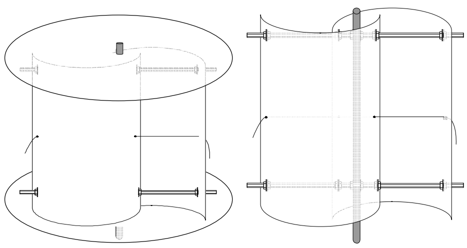
Labs Sections

We divided our students in two groups and sent them to our labs and workshop, so that everyone could get a first experimental contact with basic notions and workplaces. At the workshop the purpose was to see the equipment they would use (and how to operate it), the rules while working at a mechanical workshop, names and types of elements to find in a wind turbine and basic information of mechanical content that would later be of use while building. In other labs (Electromagnetic Lab and Electrical Machinery Lab) they saw specific phenomena (with appropriate measuring devices) at work, focusing on induction and power generation. The (experimental) sessions they all attended were:

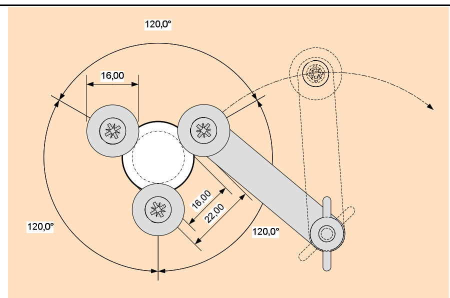
L1 Becoming familiar with tools: from screwdrivers to bolts. Safety issues.
L2 Mechanical sessions: bearings and couplings – the real thing.
L3 Introducing electricity basics: electrical measurements, basic electrical laws, ac & dc, electrical energy and power; electrical conductors.
L4 Electromagnetism: seeing/experimenting with phenomena. Experiments with pm motors.

Although this is uncommon for exploratory projects we were granted full access to the Mechanical workshop and total cooperation from our colleges at the Mechanical Department at ISEP.

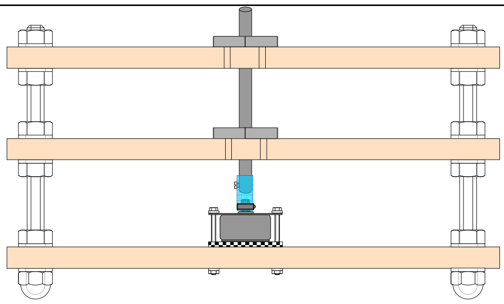
Hands-on



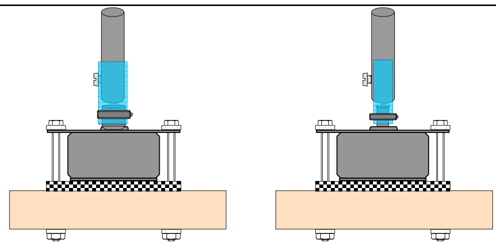
Turbine with and without covers.



Detail on bearing positioning around shaft hole.



Supporting structure.



Two elastic coupling strategies: hose outside shaft; hose inside shaft.

Figure 6: Drawings from *student project assignment*

An important part of CDIO Syllabus’ focuses on Interpersonal Skills: Teamwork. These kind of “oriented” experiences are an interesting field for introducing effective teamwork. The survey performed at the Reception morning allowed to identify some of the background of each student and eased the compliance with the rules that we would present for team building: Every group of 5 students will have students from both curricula present: the mechanical engineering students and the electrical engineering – power system students.

The first step was team building, to be done by the students respecting the hybrid group rule. Once the students presented the names of each group member, they had to designate: a team leader, a team member responsible for tools and project material and another team member that, at the end of the day, will organize workshop clean up. This last task was performed by a member of each team simultaneously. Every group was given a box filled with all the necessary materials. They had to label the box and other relevant items, perform a check up of items according to a given check list and ensure proper use of tools within the group activity.

The dimension and structure of the project induced the need for task assignment inside the team regarding the construction phase of the Savonius VAWT and respective stand. A part of the group would build the Savonius while the other part would build the stand (Figure 6). Figure 7 depicts two of the groups: on the left side 4 elements of two different groups (2+2) are building the stand while the 3 remaining team members of one of the groups are cutting the Savonius buckets. Each team would work as a complete group during the test of their prototype. This "division" was the students' decision since they soon understood they would not have enough time to build and test unless they divided tasks.

Figure 7. Students Building the Turbine Stand (left) and Cutting Turbine "Buckets" (right)

Working in the mechanical workshop of ISEP allowed access to special tools, but these had to be "shared" by different teams, during construction. A possible scheduling conflict between teams would have taken place if some of the students, in a very smooth and natural way, had not worked between themselves a schedule access to tools for the groups. The students responsible for this were issued from pre-college technological courses. One amazing detail was that, although there was a contest at the end of the week, teams developed a strong sense of cooperation between them and those students having prior experience in workshop work were helping others, regardless of the team they were in. At this moment there was a joyful ambiance in the workshop, with every one very busy …and cheerful.

To test each VAWT we offered only two sets of testing equipment and just one anemometer. A dynamic timetable for group testing was established: each group allocated a 15 minute time slot for testing and team rotation around each test site went on smoothly (Figure 8). Tests involved not only measures (voltage, rotational speed,…) but also changing turbine dimensions, accordingly to the theory presented during the Lectures, to compare and choose the best layout in terms of turbine performance for the contest.

Figure 8: Students tuning and testing their prototypes

Contest Day

For the IEEE-RWEP proposal the main points to observe in a contest scenario were:

- VAWT start-up
- VAWT ease of spin
- Voltage output level

For the ISEP project there were a few extras added:

- VAWT start-up & elapsed time until stable rotation
- VAWT ease of spin – velocity [rpm]
- Voltage output level [V] – with and without load
- Turbine parameters estimated using data collected during the test phase.
- Aesthetics
- Quality of execution/building
- Improvements done over the original (proposed) prototype
- Presentation and explanations given to the jury

The panel was composed by all the teachers involved in the project during the week and representatives of the school head office. The jury evaluated every project and questioned each team, punctuating each element of evaluation on a scale [1-5].

Mesurements	weight	G1	G2	G3	G4	G5
VAWT start-up – 0º	2	1	1	1	1	0
VAWT start-up – 90º	3	1	1	1	1	0
VAWT speed - Fan speed 1	5	4	5	1	3	1
VAWT speed - Fan speed 2	5	4	5	2	1	3
VAWT speed - Fan speed 3	5	5	4	2	1	3
VAWT voltage - Fan speed 1	5	4	3	5	2	1
VAWT voltage - Fan speed 2	5	1	3	5	4	2
VAWT voltage - Fan speed 3	5	5	2	4	1	3
VAWT speed with carge - Fan speed 1	5	5	1	3	2	4
VAWT speed with carge - Fan speed 2	5	5	1	4	2	3
VAWT speed with carge - Fan speed 3	5	5	3	4	2	1
Turbine parameter 1	2	1	2	2	5	4
Turbine parameter 2	2	5	4	1	1	3
Turbine parameter 3	2	5	2	1	4	5
Turbine parameter 4	4	3	2	5	1	5

Jury analysis	weight	G1	G2	G3	G4	G5
Aesthetics	2	2	1	4	5	3
Quality of execution/building	2	1	4	3	5	2
Improvements	5	2	5	3	4	1
Presentation and explanations	4	1	2	5	4	4

Final result

	TOTAL	Results
G1	249	1
G2	207	3
G3	232	2
G4	175	5
G5	180	4

Figure 9: Evaluation Grid for the Five Groups at the Contest.

From IEEE-RWEP adapted project to CDIO standards 7&8

IEEE-RWEP guidelines imply a design already established leaving little room for conception and design of solutions on the part of students. *In many EE/CE/CS/BE/EET programs, current first-year curricula focus on the theoretical and mathematical components of engineering. The vehicle for change is a series of IEEE-approved hands-on projects that teachers will be able to use in the first-year classroom in order to "adhere" their students to these disciplines* [6]. This implies that the projects are meant to raise awareness and, of course, questions, while driving students to a more focused attitude in learning in the first years.

The project experiment at ISEP took place bearing in mind the scope of CDIO standards 7&8.

Students had to build a prototype based upon a set of guidelines and had to do it in a very short time interval. They could make improvements to the prototype and could also improve the prototype aesthetics. The team had to agree on “what”, “how”, “who”. Hybrid teams (mechanical and power system) developed an interesting exchange of views and knowledge between team members, although at first, the idea of hybrid teams didn’t attract students that much. In this sense, we could see improvement in *personal and interpersonal skills,* as well as in every team’s building skills.

Active learning was undeniably present throughout the evolution of the project. It took particular relevance when teams got to the test of the turbine and had to collect data to estimate turbine parameters. Every project needed tuning otherwise the turbines had difficulties to start-up, maintain a steady rotation or produce a visible amount of energy. Brainstorming among team members was intense and, in the end, most of the teams managed to overcame their faulty details. At this stage, the previous informational sessions they had received started to make sense in their minds. It was the experiential reality that helped clarify the nature of the information provided days before.

The high degree of satisfaction with this type of approach first appeared on the first day of construction. At lunch break, and in every other day, this situation would repeat itself: students almost skipped lunch just “for the fun” of working longer in their projects. The following morning, students were expected to start working at 10:00 am. The workshop technician starts working at 9:00. He mentioned his surprise to see teams sitting in the corridor by the workshop door, anxiously waiting to pick up where they had left the day before, even if it meant starting earlier than scheduled.

SURVEYS AND ANALYSIS

There were three surveys done. Survey number 1 was done during Reception Morning. Survey number 2 occurred after the contest, in the last day and survey number 3 took place 6 months after the project corresponding to the end of these students’ first semester at ISEP.

Surveys were expected to enlighten issues like:

- Understanding student background
- Understanding student expectation
- Feedback on project organization and contents (materials, tutoring, duration)
- Student self analysis of the week
- Student’s comments

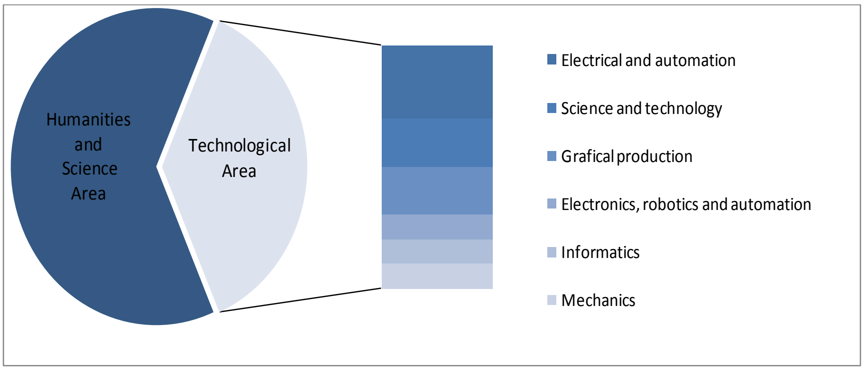
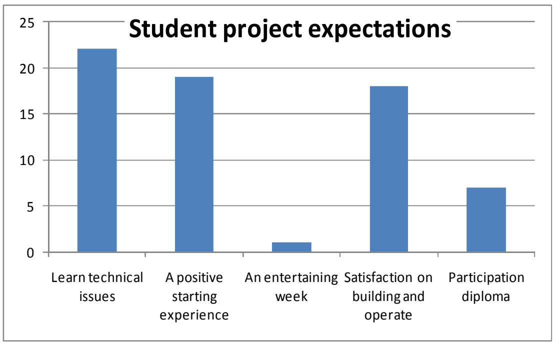


Figure 10: Student Previous Background (30 answers)

Figure 10 shows the background formation of the students participating in the project. How do these areas relate to the particular engineering formation chosen by these students? The answer would be: Not much. A student pursuing previous studies in Humanities and Sciences can apply for Medicine, Biology, Archaeology and, of course, also Engineering, just to mention a few. Amongst those students that said to have a pre-formation of a technological area, only 4 had that pre-formation matching the specific engineering curriculum chosen. Figure 11 shows the students expectations and opinions about this type of approach.



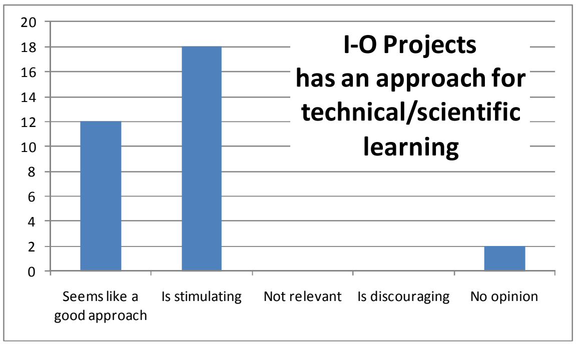
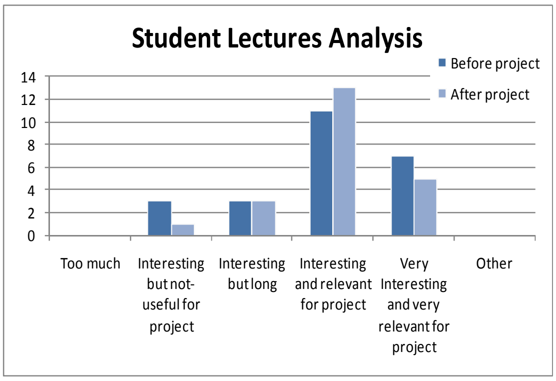


Figure 11: Student Project expectation and impressions on I-O projects

Adapting lectures and sessions from the initial 2 week project (with quizzes, brainstorming sessions, etc) into 1 week, maintaining only the lectures and lab sessions could pose problems. In spite of the situation students did like the lectures and lab sessions



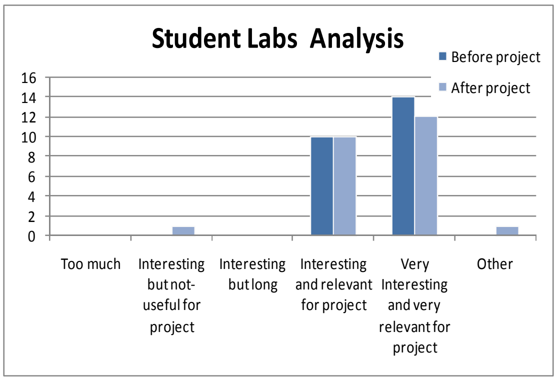


Figure 12: Student Lecture and Lab Session impact evaluation before starting to build the project and after finishing the project

Figure 13 summarizes the general impressions the students had about the experience.

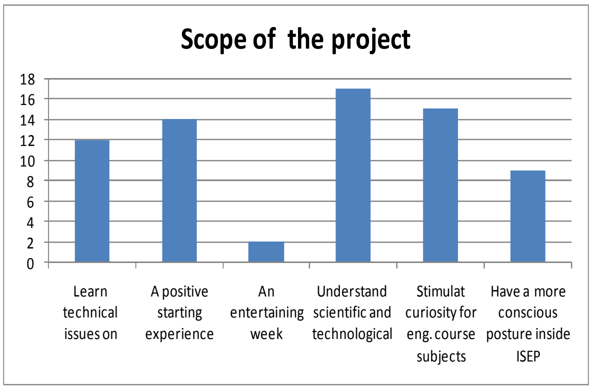


Figure 13: Students Impressions on the Scope of the Project

Some Of The Students' Comments

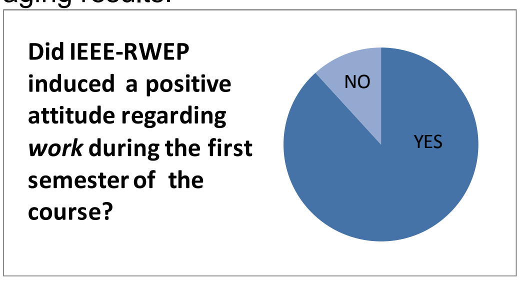
Positive comments

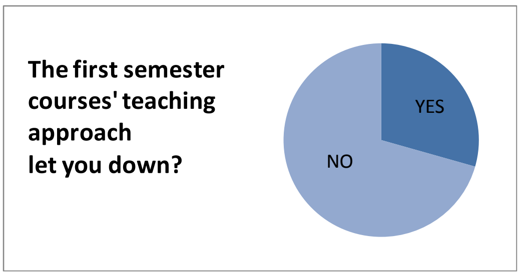
- [The Project] helped me gain new working methods and stimulated even more my interest in this field of engineering (renewables).
- It helped me a lot to understand better the wind turbine theme. Very enriching.
- It was very interesting and stimulated my curiosity in this field of engineering.
- It was undoubtedly a good experience and contributed with relevance to my opinion on renewables.
- The project was up to my expectations; it was interesting at every level; it was very demanding and hard working but it was worth it and besides, a students´life is one of hard working.
- It was important for my technical development in engineering.

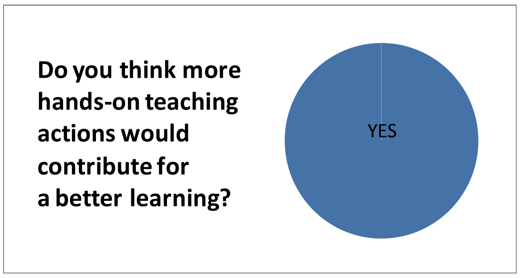
Negative comments

- It was much harder than I expected.
- Uncomfortably, extremely demanding.
- Too little time given for the project.
- Some lectures: a bit too long generating a sleepy feeling.

The results of the (brief) third survey performed after their first semester at school, show encouraging results.







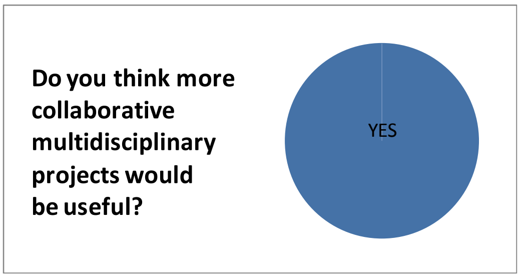


Figure 14: Reflections over the relevance and nature of the experience.

Analysis

The surveys show that students had, from the start, a concern about learning technological and scientific issues and they expected this experience could help them in that sense.

The importance of the lectures was only fully perceived after building the turbine and having to tune it, using the theoretical information previously given. This is an important fact since it may have a positive impact in their posture in future (classical) lecture classes. This can be a possibility if one sees the opinions collected after their first semester.

When invited to look back, the teaching methods encountered didn't disappoint them. Could it be that the experience, setting the foundations for a better acceptance of traditional lectures, led to a more effective learning? Most students felt the experience had a positive impact in the first semester of classes and that these classes were not disappointing.

The students were unanimous on the importance of these projects for better learning outcomes and collaborative multidisciplinary issues.

CONCLUSIONS

It is clear for those of us that saw the students' interaction between them and between them and teachers that the project somehow "opened" not only their minds but also their spirit, changing what was, at first, a distant posture and also one of a certain cynical disbelief, into genuine and warm attention and willingness to participate with teachers in the discovery of every new information or observation.

From the experience the following outcomes where obtained:

- <u>A welcome project should be optional</u>: Involving a greater number of students is fundamental although the issue of scalability along with the issue of the projects' theme is complex. For an entire school to manage an extensive action it would be advisable to have a set of different projects. It is important to let the student choose as a first involvement in school;
- <u>Welcome projects must be technically and scientifically appealing:</u> This may set the right tone for good student embracing of content in all future courses;
- <u>Engineering must have a purpose:</u> Projects addressing the relief of some environmental or social/humanitarian problem drives students to dedicate themselves more profoundly to their work, as if in need of a higher, more serious or more relevant goal in the process of learning to become engineers. The IEEE-RWEP project database offers an important

set of well structured projects to implement and adapt, in any school of engineering, for first year students while observing social, humanitarian and environmental concerns;

- Involvement of colleagues is fundamental: The IEEE logo helped to get the cooperation of colleagues and remaining school staff. It seriously moves teachers' curiosity and reminds how crucial it is to rethink engineering teaching and engineering curricula. It would have been impossible to develop this experience at ISEP if it wasn't for the cooperation of some of our peers, the full support of the school head and also from the departments associated.

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