Classical Engineering Education Revisited - Why it Matters

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Classical Engineering Education Revisited - Why it matters?

Abstract

This paper shows an engineering program specially designed to a private engineering school that aims to become the best one in the region. The Engineering Education Team of COPEC – Science and Education Research Council has designed this program that is knowledge centered and specially challenging, which integrates classical engineering approaches and real experience in order to achieve a high level of engineers ready to perform as professionals or researchers. It aims to form the Engineer – a professional that is capable to learn for life and be creative in many ways.

Keywords: tools of learning, best practices, work market, intellectual skills, knowledge-centered

Introduction

How can engineering colleges prepare our future engineers - engineering students for the real tests of life? How can one train in a way, which may not yet exist? How can education institutions provide students a strong and valuable knowledge? An idea came up! And it is: if students are taught the skills of learning, then they will continue to learn on their own for the rest of their lives. How is this possible? By the well-walked path of the tried and proven — the classical method of educating engineers.

It is about classical education not as synonym of Christian education, but as the education with solid basis of knowledge in basic sciences and basic sciences of engineering. Students then will finish their course equipped with the right tools and a strong capacity of learning. Classical education then, in this sense, is a life-long process of applying the “tools of learning” - tools that are skills entailed in basic sciences, engineering basic sciences, and specific of engineering, which travels with the student through her/his career as professional or as an academic. In other words, the market seems to be ready for those who obtain a general engineering education and develop adaptable skills that will serve them while their world continues to evolve [1].

Knowledge is more like a web than a chest of drawers. There are no subjects that are unrelated to others. It happens the same with engineering training; the program is a web of knowledge, provided by studies, delivered in a time frame, interconnected and necessary to get the pertinent knowledge and development of skills that will enable them to learn by themselves. This is why students have to see the big picture from the beginning. It is important to show them, in the first week of classes, the whole program, as a big frame and its parts and the details of each part. It is a way to locate them within the program. It is hard but not impossible and it the effort is worth. The knowledge of the entire program has an effect in students who can see the value of solid knowledge in basic sciences as a start point for their formation and the importance of these as valuable tools.
It is important to remind the students that education is not an abstract term. It is established in cultural economic, individual, philosophical, scientific and social advancement. In other words, education is the mean for developing the mind for the betterment of the individual and society. Advances in science and technology mean that the world will continue to change rapidly, so that the knowledge learned by students in specific careers will have a short lifespan. In contrast, those who achieve a general engineering education will develop adaptive skills, which will serve them while their world evolves. Since people tend to change jobs and occupational fields several times throughout their lives, it is important to acquire a dynamic ability to absorb information, to adjust to organizational goals, and to navigate through complex work relationships; for this reason, a classical approach seems more useful for today’s work market.

The integrating part of the program comes from internships and practical projects, which are relevant for both: student’s studies and the real work scenario. The internship and the project offer opportunities to take the skills they are developing in the classroom to the real world. So, School provides internships in companies, in the field of student’s choice during the fourth and fifth years of college. They are then, at that time, more prepared to face these challenges [2].

The authors use "classical education" meaning knowledge centered education and refer to "classical method of educating engineers" as the same kind of approach. It refers to the choice of in class classes with face to face interaction, strong and deep study mainly in mathematics and physics as the basis for the quality education that provide the tools that engineers of conception or application need.

**Problem Formulation – New Market Demands**

An engineering school of a private University decided to invest in a new civil engineering program, instead of opening a new program in another field, once this program is still the most sought course by young people in the region.

In order to overcome the difficulties of the hard competition and external evaluation of programs, the University has hired COPEC – Science and Education Research Team for Engineering Education, which has designed a program, which is knowledge centered and specially challenging. It is a program that integrates classical engineering approaches and real experience, in order to achieve a high level of engineers ready to perform as professionals or researchers. Their goal is to train Engineers able to learn for life and be creative in many ways.

The program has been specially designed, and aims to become the best one, in order to attract more students due to the competition in the region, that despite of being a relatively small region has five other universities offering the same program of civil engineering and faces also the external evaluation process by the Ministry of Education [3].

**Timeless Education**

The classical/general education (and here as opposed to progressive education) is a type of education that has a history of over 2500 years in the West. It began in ancient Greece, was adopted widespread by the Romans, reduced after the fall of Rome, made a slow but steady
recovery during the Middle Ages, and was again brought to perfection in the Italian Renaissance. The main goal of classical education, in any level, is to form the whole person, in accordance with timeless intrinsic values; it is a very effective way to form free citizens, as opposed to controlled citizens.

The classic view of education states, essentially, that human beings are intelligent beings, which means that human beings want to know things, more specifically to know what things are and how they work. It is primarily focused on knowledge and not student-centered [4].

At University level, the classical/general education demands self-discipline and it produces intelligent, curious young professionals, who can think, calculate, analyze, understand, solve problems and follow through on a wide range of perspectives. It is systematic and rigorous; it has goals and a method to reach the goals. It provides future professional the tools to learn and to adapt to the new work environment, as well as to the mutant work market of this millennium.

Looking at History, the classic engineering was responsible for the appearance of weapons, fortifications, roads, bridges, canals, tools, etc. In ancient times, in the eighteenth century, the first engineering schools emerged in France. They are: the École des Ponts et Chaussées (1747), the École de Mines (1783) and the École Polytechnique (1794), it was the period when Science married Engineering. They all belong to the group of French Schools that constitute mostly the so-called "generalist" Grandes Écoles, and the leading ones, of these groups, constitute the major part of the French scientific elite education system [5].

In the field of science research what has been seen is that research work is not based on a top-down command-and-control hierarchy anymore. In this new virtual and complex system, scientists combine and recombine in research teams, based not on academic discipline or institutional affiliation or geographic location, but on the unique requirements of the problems they want to address. It means that researchers do not have to be in the same place of their collaborators, nor have they to be in the same place as the problems they seek to solve. There are international networks, which are more important to individual faculty members, than their departmental or institutional ties, since this network enlarges the possibilities of research and career success [6].

Besides this, the time is coming, when most people will have a number of jobs before middle age and when many jobs have not yet been developed; the question is: how can educational institutions form or train in a manner that may not yet exist? The classical/general education curriculum provides an answer.

**Methodology – The Classical Education Revisited**

Classical/general education can be defined both: as a curriculum for broadening the mind—one of the hallmarks of an educated person—and as a way to prepare for active participation as a citizen. At present time, there is a sense that classical/general education should focus in the key attributes that employers value as needed by a generally educated person: critical thinking, writing, speaking, arguing, researching, and mathematical reasoning. In addition, to introduce a broad variety of subjects, classical/general education should exercise skills and habits of mind.
After the Second World War, with the cold war, and the run for the moon, education suffered a big change, added by the enlargement of students in University. These changes were necessary, however, due to the challenging and mutant educational environment as well as the global market and the scientific and technologic new achievements it is rather difficult to figure out what kind of engineers training will be necessary. In order to face the new challenges, the classical engineering training is an approach that provides new engineers the right tools to perform and to learn for life [7].

As mentioned before, in the high competition for success, private universities are struggling to attract good students for their programs, once it guarantees the continuity of the colleges and programs. The external evaluation that programs and colleges have been facing, push them to enhance the quality of the programs that they offer.

For these reasons, to attend the necessities of an engineering college of a private university COPEC’s team has chosen to propose the pursuit of a classical/general education approach for the civil engineering program and so form the “Engineer”. The engineer who has knowledge and self-taught skills - a professional who can think, calculate, analyze, understand, solve problems and follow through a wide range of perspectives - social, economics and of sustainability among others. It is a way to attract good students to their programs, as it ensures the continuity of colleges and programs.

It is essentially, what says a famous and very appreciated Chinese Proverb -“Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime”.

The program started in 2014 and the enrollment was low, comparing with previous years. However, after three years, the results have been very positive taking into account the trend of engineering programs, choices in young generation and the competitiveness in the region.

**Engineering Education – Facing global market**

The proposal of a classic engineering program came as a response to develop a new educational approach with the goal of strengthening a civil engineering course that saw its enrollment declining each year.

The key elements are:

- have a well conceived, coherent, sequential curriculum
- have all courses with strong and pertinent knowledge
- adjust other parts of the education system of the program to support the goals of learning
- provide teachers with a carefully conceived curriculum, filled with challenging texts and materials
- provide students where they are going and how they are going to get there.
It is necessary to challenge students to acquire the knowledge that they really need to become engineers; a professional capable to do any work and overcome the unpredictable future when it is becoming difficult to anticipate the new professions and opportunities that will be needed [8].

The process is long, implies many changes, including teachers trained for the program and the achievement of the main objective, which is to foster in the students the analytical and verbal skills, creativity and innovation, entrepreneurship, the appreciation of complexity and ambiguity, and leadership, very important for the formation of the engineer of this millennium.

The curriculum has been set and discussed with set of professors, specialists in their fields of expertise, and in accordance with the Law of the Ministry of Education, the organization that regulates and accredits University Schools Programs.

The curriculum is organized in a way to provide students basic sciences courses, taught during the first two years; followed by basic sciences courses of engineering deployed during the second and third years and the specific courses of engineering, in this case, civil engineering, with emphasis in concrete constructions and eco building construction (following the trend of sustainable buildings – energy efficiency and use of low emission of Co2 materials) [9].

The figure below shows a block of different courses that were added and they have been taught in a period that has been named as Pre – Program, which happens two weeks prior to the year schedule, when students have classes of Language usage, Instrumental English (usage of technical English), Mathematics (review of high school content) and Psychology (aspects of competitive and demanding pressure environment).

So the program design is as follows:

![Diagram](image)

**Figure 1. Block of different courses that were added in a period that has been named as Pre-Program**

**The Curriculum**

Bellow, there is a chart of the basic cycle curriculum, that covers seven subjects in the first semester of the year of admission of the student in the Civil Engineering course and eight subjects in the second semester, totaling 27 credits in the first semester and 28 in the second semester. The content of subjects are taught deeply and with intense exercise sessions. It starts in the pre-program and lasts for all years.
Table 1. Basic Cycle Curriculum.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>CC</th>
<th>CW</th>
<th>TC</th>
<th>OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Physics for Engineering I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Experimental Physics for Engineering I</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Introduction to Engineering Computing</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Differential and Integral Calculus for Engineering I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Linear Algebra for Engineering I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Design for Engineering I</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Introduction to Engineering</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>General Technological Chemistry</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discipline</th>
<th>CC</th>
<th>CW</th>
<th>TC</th>
<th>OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Physics for Engineering II</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Experimental Physics for Engineering II</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Numerical Calculus</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Differential and Integral Calculus for Engineering II</td>
<td>4</td>
<td>0</td>
<td>4</td>
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</tr>
<tr>
<td>Linear Algebra for Engineering II</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Design for Engineering II</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mechanics I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Introduction to Materials Science for Engineering</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>28</td>
</tr>
</tbody>
</table>

CC – Credit class  CW – Credit work  TC – Total credits  OC – Overall credits

First Results

2016 is the third year of this Civil Engineering program and the results are as follows

Table 2. Civil Engineering program.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Total of students that have entered in the Civil Engineering Program</th>
<th>Number of students of civil engineering that have opted for the Classical Engineering Program</th>
<th>% of enrollment rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>180 students</td>
<td>89 students</td>
<td>49.44%</td>
</tr>
<tr>
<td>2015</td>
<td>180 students</td>
<td>100 students</td>
<td>55.56%</td>
</tr>
<tr>
<td>2016</td>
<td>180 students</td>
<td>136 students</td>
<td>75.56%</td>
</tr>
</tbody>
</table>

The table is based only on the enrollment number of students in the first and following years of program.

Expected Outcomes

The initiative proposes specific learning outcomes and competencies such as:

- Applied learning: used by students to demonstrate what they can do with what they know.
- Intellectual skills: used by students to think critically and analytically about what they learn.
- Specialized knowledge: the knowledge students demonstrate about their individual fields
of study.

- Broad knowledge: transcends the typical boundaries of students of higher education and encompasses all learning in broad areas through their solid knowledge in basic sciences and specific of engineering
- Civic learning: enables students to respond to social, environmental, and economic challenges at local, national, and global levels [10].

Discussions and Conclusions

More than ever, it is necessary to form professionals equipped with tools that enable them to respond quickly to the changing work market and the unpredictable new professional expertise fostered by Scientific and Technological development.

There is a trend in engineering colleges to teach less mathematics and physics content once particularly these are the subjects that hold students back. This seems to be one of the causes of such a poor students performance. Presently there is not any surveys of the students to determine in what way this group is trained better and/or has better skills, however it is estimated that during the internship period as they show better knowledge of mathematics what seems to enhance their performance. This is the conclusion that the survey applied every three months, among institutions that received the students as interns have showed this difference when they graded students’ working performance. By better performance it means that students can cope easier with the challenges and difficulties of problem solve and a better understand of modeling importance to search for best solutions.

The present professional needs to acquire a dynamic ability to absorb information, adjust to organizational goals, and navigate in a complex work environment. For this reason, a classic approach seems more useful for the demands of today's job market. It is at least interesting that the classic approach is being neglected, at a time when its product might be more interesting.

The design and implementation of this program has been very positive so far. The first group of students, who will graduate in 2018, the students who are in internship at the 4th year have showed better performance comparing to the other program, which is a first step to success. It means that the students have better grades principally in the second and third years of the program so far. The Pre – Program in special has a good effect in students once it provides them some elements that they can use such as Psychology and technical English.

The internship period that is recommended in the 4th year of the program has just started and the engineering college has been working to help students to find good ones. It is crucial to advise them and to ensure proper conditions in accordance with the laws, in order to avoid waste of time and possible misuse of qualified labor.

This program which knowledge centered is responding very positive in terms of students’ enrollment and it is necessary a survey to figure out what are the elements that make the students opt for this kind of education: the different approach, the strong knowledge basis or the possibilities of performing in any filed of civil engineering along the career of their choice once the present market is mutant and challenging. It is the next step for the year 2017 research for
this program that will take place at the second semester of the year. In fact the results will be known in the beginning of year 2018. The goal is to refine the program advertisement as well as to provide an input of what really has been working well and the flaws.

Acknowledgment

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