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Abstract — This paper intends to show a project developed by the organization that has been implemented in an engineering school of a private university, resulted by a large experience designing and implementing pedagogical projects developed in order to make teaching learning process more efficient for engineering schools. In this Century technology has reached such a sophisticated level, which people are immersed and that is let's say the ignorance of many and the knowledge of few. Although Communications are more and more efficient working as an element of integration and off boundaries, the new technological scenario has brought also some not very good consequences such as jobless. It is due to the level of complexity that a job now has, in other, words it is because of this characteristic that makes working environment more demanding. So it is necessary to create and foster approaches that align with this reality and support young professionals in the 21st era.

Keywords — complexity; work market demands; pedagogical aspects; problem solvers.

I. INTRODUCTION

Along the years of existence the History has showed how men are beings of great capability to change and manipulate the world that surrounds them. This capability is inherent and is let's say "a blessing and a curse". Anyway this capability has been working for good fortunately. Let's just look at the development that humankind has achieved. It is possible now to live more and better, machines now take care of heavy work leaving to men more time to work in other services enhancing the quality of life. Not to mention the medicines that play a great deal in the cure of many diseases, which in the past were plagues. New technologies are making communications more and more efficient working as an element of integration. By the other hand the experiences have brought also some not very positive consequences such as jobless because of the level of complexity that a job now has a characteristic that makes life more demanding. So let's say that technology at this sophisticated level, which people have developed is the ignorance of many and the knowledge of few.

In engineering field the most important aspect to be taken into account is to form engineers ready for this new brave world extremely complex that demands solutions out of this world. It is crucial to rethink engineering education viewing the

future that as it has always being, unpredictable and consequently challenging. So the answer is to engineer engineering programs that can respond to this need.

Essentially the description of the job of an engineer can be defined as: to identify and find solutions to problems of a concrete and often complex technological nature related to the design, realization and use of products, systems or services. This aptitude arises from an ensemble of technical knowledge on the one hand and economic, social and human experience on the other hand, with a basis in sound scientific training.

Currently the main areas of activity for engineers are in industry, construction, agriculture and the service industries. These activities mobilize human, technical and financial resources, usually in an international context. It receives economic and social sanctions and is concerned with protecting man, life, the environment and collective wellbeing.

An engineer must acquire a range of knowledge and know how during the course of a long cycle of higher education organized in an institution approved by the competent organization of accreditation in every country, and including multidisciplinary academic teaching as well as periods of work experience, in general.

A way to overcome some challenges in engineering programs viewing the future may be by just bringing some solutions that can in some ways help future engineers to do their job as problem solvers as good as possible and to engineer their careers as well.

II. COPEC

COPEC – Science and Education Research Organization that is a multidisciplinary organization, a leader in working for the advancement of education and science and its applications for the development of technologies in the service of society.

Integration activities promoted by COPEC provide the creation of quality partnerships because COPEC is an organization that brings together scientists who share the mission of promoting and developing science, technology and education.

The activities, content, and services provided by COPEC, through courses, publications and consultancy, with national and international experts contribute to the promotion of the professional who wants to stay well informed of new scientific technological achievements.

COPEC enjoys respect and international recognition characterized by open discussion, free exchange of ideas, serious debate and a commitment to rigorous research.

Its most recent achievement the IIE - Institute of International Education is a bold and resilient source of innovation in higher education. It provides quality courses in different fields of science. It is an international organization with its head quarter in Europe [1].

It is the organization that has designed and implemented several engineering programs in different institutions and environments with success.

III. DISCUSSIONS ABOUT PEDAGOGY

History is a fundamental element to understand the present. It is important to look back and rethink the practices. It is a helpful way to learn with the mistakes of past and make present better. In education it is not different, it is important the constant review under the perspective of its importance in the promotion of human beings. It means that it is the basis for a strong action with impact in people's life.

Teaching and learning in higher education historically has been through many waves of theories and practices in the search for its betterment. Since the ancient and medieval periods, and lately with technology advancement and the concept and practices of a societal system, it has changed drastically. It is possible to say that over several centuries of development the practice of teaching has been transformed from a educational function into a very complex profession. It is currently a very specialized profession involving pedagogic principles and practices designed to provide unique and quality services to meet the educational needs of the individuals and societies.

In the beginning the pedagogic principles and practices were mainly based on casual observations and have evolved to more organized observations, and generalization of experiences. Only later on based on philosophical and psychological postulates and theories that emerged during the last two millennia [2].

With the vast territorial and consequently economic expansion the early Modern age has witnessed the rise of a large middle class as the merchants, artisans, officials and others. This event reinforced the spread of literacy and scholarship because the middle class possessed the time and wealth to become literate and pursue scholarly activities. Literacy and education of a large middle class had an impact on the social structures causing a social change in Europe between the Renaissance and the Industrial Revolution. One event that has helped to evolve even more the literacy is the technology of printing on paper, which made it possible to distribute copies of the texts, giving much greater incentives for the literacy.

The Industrial Revolution boosted the development of capitalism, industrialization, nation states, and science, as well as a major expansion of European interests into the rest of the world. It was seen as a time of great progress and development.

In the so-called postmodern era it seems to have emphasis on multiple paths and plurality, diversity and on the partiality of all knowledge. This is the idea that it is possible to achieve only an incomplete image and the idea that all knowledge is partial. Another aspect that can be noticed is that changes are perceived not as a linear progression, but as a series of networks, flows, connections, reconnections, because they are always forming and updating and thus not having time to set.

Two events in Present World have a strong impact in high education and they are: the advent of Open Education and the integration of Information and Telecommunication technologies. Both led to increased access, individualized learning and enhanced human interaction and shifted the control over education and learning from teacher to the learner [3].

Under this perspective the authors it becomes necessary to think and discuss Education Pedagogy viewing the future [4].

IV. UNIVERSITY EDUCATORS IN 21ST CENTURY

High Education Pedagogy has become one key factor for the success of a program that reflects on the quality of teaching/learning process.

One of the important actions in high education currently, no matter the program is to have the teachers trained and aware of pedagogical aspects of high education.

The characteristics of a teacher in high education comprehend: to be ready to do research and analyze problems in their field of expertise, as well as act as consultants. It is a way to keep up with innovations in pedagogy and project development [5].

It is important that the teachers are supportive to strategic program planning development as well as to the extra class activities; not to mention managing development projects, support innovations in the courses, support and foster leadership and quality management in projects, which results permanently reflect on her/his activity as educators.

And finally it is necessary to be committed to continuous professional development and demonstrate ethical commitment in support teaching and learning.

V. UNIVERSITY STUDENTS CHARACTERISTICS IN 21ST CENTURY

Based in the several researches and projects development and implementation COPEC Education Research Team has developed the description of some very valuable characteristics, which students must acquire along the university study period.

In 21st Century with all challenges that all sectors of society and worldwide for higher education are subjects for students there are some characteristics that should be developed while studying. The list is rather long however the

acquisition of some let's say skills are of great value for life. They are abilities, skills that can be adopted for life because of their richness and efficiency in the development of a career.

So students must develop positive attitude towards study, which means that students must demonstrate that they are ready to work hard and that they are be able to cope with the workloads of their chosen course and thrive at a higher level of education. Besides an inquiring mind is also a valued characteristic.

Students must demonstrate a passion for their chosen career. Independent extended interest in a subject that goes above and beyond what is required in the classroom. Ultimately, passion and perseverance are qualities that are also highly sought after by employers, not just universities.

Students must pursue the development of the ability to think and work independently to think and learn independently. And also students must strive to develop an ability to work well in groups, to be a good team player. Have the ability to adapt to many environments, wear many hats and interact with a diverse group of individuals.

Besides it is important to develop social skills and, even more worryingly, common sense in all activities and choices. They must be patient, diplomatic, listen people and to be ethical.

Among personal characteristics is the development of self-control that is the ability to stay calm, assess the self, and then make adjustments. If people are capable to control the emotions and reactions to the world, to others they can better control the outcomes.

Students need to show commitment and determination, or show an ability to persevere and complete tasks meaning that they will complete their course and have an understanding of what it entails.

It is important to have the knowledge of mother language, writing well, with no spelling mistakes besides the ability to make clear statements. It is necessary to be able to write good reports and make good presentations, in other words to be proficient readers and communicators.

As future professionals they must develop technical competency, to be creative, resourcefulness and continuously drive for improvement.

VI. FUTURE ACTIONS

These are times of great challenges and deep changes. Therefore currently employers expect graduates to have attributes including team working, communication, leadership, critical thinking, managerial abilities, in addition to a knowledge of their degree subject and above all problem solver. How can university cope with these demands?

It is now a demand for engineering schools and it is time to rethink engineering education.

- if the students are taught the skills of learning by themselves, then they will continue to learn on their own for the rest of their lives.

How is this possible?

To answer this question it is important to see education under the perspective of organizations that dedicate efforts to make engineering education for future. One of the means, for a start should be the integration of digital technologies and proved good pedagogies should form integral elements of higher education institutions' strategies for teaching and learning. To establish clear goals and objectives should be defined and necessary intern organizational support structures established to drive implementation [6].

There are many ways to foster the formation of engineers for the unveiled future once it when new professions will rise and others will disappear. For this reasons it is important to prepare the engineer to face the challenging, unpredictable and mutant working environment of years ahead.

The best way is to provide them with a valuable formation that only the classical/general or what can be named of "good engineering education" can provide. During the program the students will acquire the tools that enable the engineer to perform as problem solvers; a 5 years program designed in a away that they have strong knowledge of Basic science, Basic Science of Engineering and Specific Science of Engineering [7] and of course use all the new technologies available as well as Blended learning, Online Learning, Collaborative, Project based, Problem based, Social media, Flipped classroom, Open courseware, MOOCs, etc [8].

One parenthesis is necessary here. It is about MOOCs. This is in part, because MOOCs has become more a global social movement – not just an educational movement. They have for sure captured the attention of millions of people around the world who are willing to learn. In this way, MOOCs could be seen as the greatest social innovation of higher education in the last century. Universities are also somewhat vulnerable, because in part of changes in funding mechanisms, more challenging workforce needs, and changing consumer demands.

Many institutions worldwide are embracing this disruptive innovation. Some institutions see MOOCs as an opportunity for experimenting in teaching and learning. In the other hand some see them as a mechanism for expanding the reach of the university, and yet others as an opportunity to gain global recognition. And I'm sure the list doesn't stop there.

VII. PRACTICAL MEASURES TO IMPROVE ENGINEERING PROGRAMS

The result of the 18 years of experience and opportunities to work with different universities and environments has led to many successful programs, which main result is a set of measures and changes to engineering courses that will certainly improve the courses and performance of future engineers.

This is part of a project of modernization of an Engineering School of a private university with the objective to enhance the quality of the programs.

The strategy is mainly the implementation of some measures that are:

- It is important to have in mind that anything is possible in this world of high technology invading all segments of human life;
- It is important to search the culture of the engineering college that intends to foster the formation of their engineers;
- Invite the teachers to get involved and present the project;
- To have a magna aula inviting a successful engineer to speak about what it is an engineer;
- Show the students the big picture of the program where they are and where they will be. It makes more understandable the why they have such and such subject;
- Competitively challenge the boys and collaboratively challenge the girls;
- Use all the technology available that can reach the students and facilitate the communication and learning process.

These actions are feasible and sustainable along the time and that will have some impact on the program in a medium time frame [9].

VIII. DISCUSSIONS AND CONCLUSIONS

Engineering careers are some of the most fulfilling in terms of the intellectual stimulation they offer at work and the financial compensation they can provide. Engineers are typically drawn to the profession by their affinity for data and analytics, complex problem-solving, and organized tasks.

Faculties are educators who serve as mentors, assisting students with the learning process, so that when students graduate, they will be confident in their abilities, well integrated into the industry and have the skills to excel.

An important point is that to remain relevant in the competitive higher education scenario and to effectively develop students who can meet the needs of present's global economy, university leadership must be creative about how to get students from student nature to professional mindset. The spirit of exploration, flexibility, innovation and experimentation must become a natural factor in the learning process, and the supply of education in general must be fast enough to evolve as technology evolves.

Unfortunately Engineering Schools in an attempt to retain students are decreasing the teaching of mathematics and physics once particularly these are the subjects that hold students back. This seems to be one of the causes of such a

poor students performance, not taking into account the weak k12 formation that young generations are having.

Teaching STEM subjects in K12 has become a necessary strategy and more than ever. Engineers today need to show a dynamic ability to absorb information, adjust to organizational goals, and navigate in a complex work environment. For this reason, a classical education 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.

Fortunately there are some measures not so difficult or expensive that can foster engineering education such as design programs that have some pedagogical aspects that are feasible and sustainable, like the ones suggested in this paper, which can make a difference for the students as well leverage engineering courses.

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REFERENCES

- [1] <https://www.ieee.org/index.html>
- [2] <http://www.copec.eu/>
- [3] T. Stock, and H. Kohl (2018). Perspectives for International Engineering Education: Sustainable-oriented and Transnational Teaching and Learning, PennState Press.
- [4] V. John; Engineering education finding the centre or 'back to the future'. European Journal of Engineering Education, 25 (3) (2010), pp. 215–225.
- [5] A. Y. Kolb, D. A. Kolb; Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education Academy of Management Learning & Education, 4 (2) (2017)
- [6] C. R. Brito, M. M. Ciampi, R. M. Vasconcelos, L. A. Amaral, H. D. Santos and V. A. Barros, "Rethinking Engineering Education" in 2017 IEEE Frontiers in Education Conference (FIE), 2017.
- [7] C. R. Brito, M. M. Ciampi, R. M. Vasconcelos, L. A. Amaral, H. D. Santos and V. A. Barros, "High Quality Engineering Program Achievement," in Interactive Collaborative Learning: Proceedings of the 20th ICL Conference - Volume 1, M. E. Auer Eds. Cham: Springer International Publishing, 2017.
- [8] M. M. Ciampi, C. R. Brito, R. M. Vasconcelos, L. A. Amaral, H. D. Santos and V. A. Barro, "Classical Engineering Education Coping with Engineering Profession Demands" in 45th SEFI Annual Conference, 2017.
- [9] C. R. Brito, M. M. Ciampi, R. M. Vasconcelos, L. A. Amaral, H. D. Santos and V. A. Barros "Classical Engineering Education Revisited - Why it matters?" in 2017 ASEE Annual Conference & Exposition Proceedings, 2017.