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3i Engineer: An Approach Based on a Brazilian-French Collaboration

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Abstract. The globalization era is setting new challenges in several areas such as: manufacturing processes, design offices procedures, educational organizations, amongst others. In this volatile world, the importance of engineers role is becoming more evident, since they are the drivers for delivering to the market all those demanded innovations. With the advances in technology, engineering education has been requested to change. Traditional approaches are not able to fulfil the expectancies of both, the students and the market. In this scenario, Engineering Schools around the world have been developing several initiatives (e.g. CDIO, Olin College, Insper Institute), making more investments in labs and equipment, devising new ways of lecturing, promoting more interactions. Compiègne University of Technology (UTC)-France and Federal University of Technology- Parana (UTFPR)-Brazil have a strong partnership since early 1990. Considering the above context, this work discusses the scope and preliminary results of a joint initiative from both universities, named 3i Engineer. It aims at structuring a joint innovative engineering course, beyond simple students exchanges, double-degree and internships in companies abroad, based on the tripod: innovation, industry and interculturality. A preparation work was conducted at both universities. A Seminar, held at UTC-Compiègne, on February 03rd-05th, 2016, involving 15 faculty members started the process of defining a feasible framework for the aimed approach. Intercultural issues emerged as a major subject to be addressed. At the end of the seminar, three scenarios were identified. Additionally, the next stages were also discussed and planned. At the end of September 2016, it is expected to select a scenario and establish the guidelines for its implementation.

Keywords. Interculturality, globalization, innovation, engineering education

Introduction

From the middle of the 1980´s, the world has experienced profound transformations in several fields (i.e. social, technological, scientific). Economies that were closed and old fashioned technologically, were encouraged to free trade, expanding and originating many multinational companies.

Such modifications were also sensed on the way engineers were educated. By that time, most courses focused on engineering science instead of engineering practice. According to Rajala [1], industry was frustrated by the lack of professional development, despite the engineering graduates being well prepared technically.

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Thus, several working groups were set in many countries in order to envision the future for the engineering education.

The engineering 2020 Project [2], using the technique of scenario-based planning, examined four scenarios. It states that innovation will be a key issue for a nation to compete properly, with engineering being essential to this task. However, engineering field will have to be able to adapt continuously to new trends, technologies and provide means for educating the next generations of engineers.

Another example is the CDIO initiative [3], which started as a binational task-force (i.e. involving universities from Sweden and the USA), that aims to improve engineering education, based on an open-architecture, that is freely available, containing: methodologies, products and templates.

Many other works could be mentioned at this stage. However, by now, it is already possible to verify the importance and extension of the engineering education challenges and discussions.

Compiègne University of Technology (UTC)-France and Federal University of Technology-Paraná (UTFPR)-Brazil are technology-based universities. They focus on structuring and delivering engineering courses. Additionally, they have been collaborating for more than 25 years. Both universities are well informed of the fast changes in: technology, demands from industry and engineering teaching. Therefore, they are aware of the need of a step forward in terms of preparing the engineers for the future. Based on the will of collaborating and their particular characteristics both universities decide to discuss and propose an approach for tackling the new engineering education demands.

The objective of this paper is to discuss the scope and preliminary results of a joint initiative from both universities, UTC and UTFPR, named 3i Engineer, which aims at structuring a joint innovative engineering course, based on the tripod: innovation, industry and internationalization.

A working framework was discussed and set, based on literature and successful experiences from both universities. The preliminary results are encouraging and motivated the group to plan the next steps.

This paper is organized as follows. Section 1 presents the background and motivation for conducting the main work. Section 2 briefly describes the methodology adopted. The obtained results and discussions are contained in section 3. The closing remarks are presented in section 4.

1. Background and motivation

This section provides an overview on the main characteristics of both UTC and UTFPR, as well as, illustrates the how the partnership between both is developing. At the end, the envisaged challenge for the future in the aimed collaboration is described.

1.1. The Compiègne University of Technology (UTC)-France

UTC is both a French national university and an engineering school, founded in 1972, with autonomous training and pedagogy and an innovation-intensive, interdisciplinary technological research program. Nowadays, are enrolled at UTC courses: i/ 4000 students in the engineering area; ii/ 380 Master´s degree students; and iii/ 340 Ph.D. students. There are more than 21000 UTC alumni in 105 different countries. Usually, a

UTC student spends from six to 18 months abroad, including one of his two six-month full time industrial internships. UTC is reckoned for its innovative approach towards preparing engineering students. Therefore, students at UTC can personalize their study profile through a rather flexible curriculum. This degree of flexibility ensures perfect coherence between personal inclinations and ambitions. The freedom the students have to choose their courses has always been seen a factor contributing undisputed qualities in terms of their decision-taking capacity. For that, UTC is always restructuring its training schemes to comply with societal evolutions and demands from enterprises. Finally, it has to be mentioned that UTC holds an Innovation Centre, which aims to stimulate innovation whatever the format and creativity, with an international vista. It is a focal point, a locus for exchanges, creative initiatives and enables those with novel ideas to update their scientific, technological and engineering knowledge bases and to exchange on their innovations with real field constraints.

1.2. The Federal University of Technology-Paraná (UTFPR)-Brazil

The Federal University of Technology – Paraná (UTFPR) is a public institution, owned by the federal government, with 13 campi located in the south of Brazil. The institution has its origin as an Elementary School for Craftsmen, founded in 1909, and has gone through changes until it officially became a University of Technology in 2005.

UTFPR campi are spread throughout the State of Paraná offering over 117 undergraduate courses, 36 graduate programs (six doctorate and 30 masters programs) as well as an expressive number of research groups. Nowadays, UTFPR has University has around 2.300 lecturers (professors, senior lecturers, readers), 1.000 administrative staff and around 30.000 students. The courses offered concentrate on the engineering areas: Mechanical, Civil Construction, Electronics, Computer Science, Food, Textile among others.

UTFPR is the only University of Technology in Brazil and the largest one offering Engineering Programs. Additionally, it has strong ties with the industrial sectors in several fields of the Brazilian economy. In addition, since late 90´s UTFPR provides support for spreading the entrepreneurial culture, via its Innovation Agency.

1.3. The collaboration between UTC and UTFPR

The collaboration between UTC and UTFPR started in the early 1990´s. Since then, students from UTFPR and other Brazilian universities normally spend one year at UTC. During this period, they participate to an intensive French course, study for one semester at UTC and then go through a six-month industrial internship. Up to now, more than 1.000 Brazilian students came to UTC. Also, every year, about twenty students from UTC are going to Brazil for one semester of study and in some cases for industrial internships. Since several years, UTC and UTFPR have joint double-diploma programs, which are followed by a small number of French and Brazilian students. From the beginning of the 1990's and up to now, a substantial number of students and faculty staff from Paraná came to UTC to do their doctoral studies. According to Schaegger [4], at that time, the Brazilian students would go to UTC to attend few courses and pursue an internship in a company located in France. Usually, their knowledge of French was very basic. Nowadays, the collaboration has changed with the students mastering better the language and the strengthening of research initiatives (e.g. M.Sc. and Ph.D. students exchanging).

As pointed by Schoefs [4], the new dynamics of the double diploma in several courses involving both institutions is a positive indicator that the partnership is functioning well. Also, the synergy with industry, allows the students to conduct their final year project with focus on real cases, either in France or in Brazil.

The students from both countries state they have benefited from either the exchange program or double-diploma. Two french students declare they present a differential from being proficient apart from French, in Portuguese and English. On the other hand, the Brazilian students mention their employability has increased, mainly amongst French companies based in Brazil.

Therefore, it is possible to identify the strength of the partnership between UTC and UTFPR.

1.4. The challenge

On October 2nd 2015, a Strategic Meeting was held between UTC and UTFPR, in Curitiba, in the presence of UTC President, Pr. Alain Storck. In the context of fast and major alterations of global economies, engineering education is going to face the rethinking of its role, pursuing the aim of preparing professionals capable of adapting themselves to an even more complex and heterogeneous environment.

At the end of this strategic meeting, it was therefore agreed to work on the design of a joint innovative engineering course, emphasizing on innovation, industry and internationalization, which go beyond students and staff exchange, having courses with double-degrees, internship in companies abroad, amongst others.

2. Methodological approach

The methodology, similar as that adopted by [5] and [6], is as follows:

1. Setup of working groups on both, UTC and UTFPR;
2. Literature review, aiming to define the state of art for engineering education over the next 20 years (from (2015);
3. Regular meetings, via Videoconference involving UTC and UTFPR group members, focusing on key subjects identified;
4. Seminar at UTC (3-6 February of 2016);
5. Preliminary findings as a result of the February seminar;
6. Two videoconferences (May to August of 2016);
7. Final seminar end of September,
8. Conclusions (economic feasibility and timetable).

3. Results and discussions

3.1. Working groups

After the Strategic Meeting, working groups were set in both universities. These groups were composed of six faculty members having experiences in educational, industrial and international affairs. A cloud driver (i.e. google drive) was set to upload de materials of interest (e.g. papers, cases, videos).

3.2. Literature background

The literature review has shown that there are several initiatives around the world discussing the challenges for engineering education. This section briefly describes the main works consulted to support the envisaged approach.

Basic works

On a broader sense, the report produced by Ernst and Young [7] indicates it its study for the Australian context, that there are five driving vectors of a change in the education sector, which are: i/.contestability of markets and funding; ii/ democratization of knowledge and access; iii/ digital technologies; iv/ integration with industry; and v/ global mobility.

The work found in [8] broadly discusses the future of the university. It is stated that the model of funding universities must change, to be feasible on the long term. In addition, it is perceived that courses should be structured for a group of globally mobile students.

On the field of engineering, King [9] discusses a set of issues concerning the capacity and robustness of the Australian education system to graduate enough engineers that will be required for the future.

UNESCO sponsored a fundamental work on the influences on the field of engineering [10]. The report identifies and explores issues, challenges and opportunities for engineering around the world. It brings to discussion the need to reinforce the role of engineering as the driver of innovation, social and economic development. For that, it is noticed the need to change engineering education, curricula and teaching methods, focusing on a problem-solving approach.

Spencer and Mehler [11] advocate that education is the pathway to support the challenges engineering is facing, mainly with the development of new methods of teaching and learning, reinforcing the students should understand the importance of working in groups, collaborating and improving their interpersonal relationships.

The report from the National Academy of Engineering [2] mentions that by 2020 engineers will be working with teams of engineers from different countries, as well as, non engineers, to provide solutions for yet unknown problems. Furthermore, these graduates will deal with large-scale systems, when they will be asked to use better judgement and critical thinking.

The CBI report [12] emphasizes that science, technology, engineering and maths (STEM) skills are the cornerstone for the future of a knowledge-intensive economy. Additionally, it discusses the low participation of woman in the STEM arena.

Engineering education initiatives

There are initiatives for tackling the engineering education challenges already implemented in several places and at different maturity levels.

The Conceive-Design-Implement-Operate (CDIO) [3] approach, aims at educating graduates on fundamentals of engineering knowledge, so they can develop and operate complex systems. The CDIO initiative provides a complete framework, syllabus [13] and standards for its implementation. Nowadays, there are 118 members around the world utilizing CDIO materials [14]. Additionally, this survey indicates that participant universities are improving their students' personal and interpersonal skills, as well as, the overall knowledge over complex systems. A project involving Chinese software engineering students and IT engineers from Japanese companies, using a CDIO approach is described in [15]. They identified the students improved their managerial and soft skills.

Olin College of Engineering was founded in 1997, seeking to innovate in engineering education [16]. Much of Olin College's curriculum is built around hands-on engineering and design projects. In this way, they expect the graduates to be leaders in solving the pressing global challenges of today [17], [18]. Olin College offers degrees in electrical and computer engineering, mechanical engineering and engineering.

On the Brazilian context, the Insper Institute [19], launched in 2015, courses on: mechanical engineering, mechatronics and computing engineering, based on the Olin College approach. Its main aim is to prepare engineers to innovate, develop products and business.

Other initiatives could be mentioned. However, these are representative and fulfil the scope of the present study.

Innovation

Innovation is widely portrayed as a key element to ensure successful competition in a worldwide economic context [6].

ASEE [20] brings to light the question on how an appropriate environment can be assembled, so engineering educational innovations can occur with desired frequency and support the education of future engineers. One of its main recommendations is to encourage entrepreneurship and competitions, so engineering students can deal with business formation and finance, intellectual property, amongst others.

The work produced by [5] aimed at understanding which elements guide the engineers way of thinking. After a field survey, the authors identified six terms that form the core of what they coined as Engineering Habits of Mind (EHoM): i/ systems thinking; ii/ problem-finding; iii/ visualising; iv/ improving; v/ problemsolving; vi/ adapting. Their main conclusion are that changes in engineering teaching should be implemented, so engineering careers could be more effectively presented to young people.

The role of entrepreneurship in engineering education is discussed by Byers et al. [21]. The authors reinforce the importance of engineering educators, who besides preparing the students with technical and analytical expertise, provide insights on how to be resilient, creative, flexible, so they can become more innovative and entrepreneurial.

Internationalization

The issue of internationalization is widely and deeply discussed in [22]. However, some particular works must be examined.

The British Council conducted a survey [23], to support the UK Strategy for Outward Mobility. Its main findings include that the motivation for the students to go abroad on a mobility program were a desire for enjoyable and interesting experiences, to broaden horizons, and to enhance employability and career prospects. Additionally, the students reported to be interesting to develop intercultural awareness, independence and self-confidence. On the other hand, in order to go abroad the availability of funding emerged first, as well as, personal safety and security, reputation or perceived quality of host and location and language requirements.

Jones [24] brings into context the employability skills (i.e. flexibility, organization, negotiation and good communication) and how education abroad can develop them. According to him, the international experience as student or volunteer can enhance the transformational learning. Additionally, he introduces the idea of creative intercultural opportunities derived from internationalization for enhancing local curriculum.

Industry

Stephens [25] states that industry, society and engineering schools should collaborate, so a sufficient number of qualified engineers can fulfil the demands from industry and market. In addition, it is emphasized the importance of students mastering soft skills (e.g. work in teams, communicate, defining problems). Two measures recommended to close the gap with industry on the demanded professionals are: i/ first and second year engineering student project; and ii/ internships.

The Brazilian National Confederation for Industry produced a report [26], which argues that a major shift in the Brazilian engineering education is fundamental for the improvement in productivity and economy performance. It highlights the importance on devising means for stimulating the cooperation between university and industry, amongst other findings.

The enhancement of opportunities to develop work-related learning and employability leverages the learning of the subject being studied, argument [27]. Furthermore, this approach induces resilience and expose students to unfamiliar situations, helping them to deal with anxiety.

Lessons learned for UTC-UTFPR

From the work conducted until this moment, the following points drew attention: i/ the pace in which technological and economic changes in the world are occurring is increasingly high; ii/ engineering plays a fundamental role in matching the market needs in a complex world; iii/ there is a distance between engineering graduates and the industry demands for professionals; iv/ this requires a redesign of engineering courses; v/ international cooperation is essential for the academic environment; vi/ innovative education tools have to be developed.

3.3. Meetings: UTC-UTFPR

From these assumptions, the groups held a set of videoconference meetings in late 2015 and early 2016. The framework for further discussion was structured and a consensus was reached.

Why 3i

From the papers examined, discussions held and profiles from both universities (infrastructure and faculty staff), the synergy between innovation, internationalization and industry (therefore, the "3i" label) was observed.

UTC is known for the quality of its engineering courses, as well as, it focus on internationalization, partnership with industry, technological research and innovation. In 2014, the Centre of Innovation Daniel Thomas was opened.

On the other hand, UTFPR has strong ties with industry and its Innovation Agency offers support for the academic community.

Additionally, the cooperation between both universities on the internationalization arena is well established and can be considered mature.

Thus, both parties decided the 3i would be the starting point for suggesting novel approaches for extending the collaboration already implemented.

The intercultural issue

On a peer-to-peer discussion, it emerged from the UTC faculty staff, that on the branch of internationalization, the interculturality issues were very influential and should be examined in more detail. For that, a conference of Dr. Pateau from UTC [28] provided the basic concepts for better understanding the importance of considering interculturality in the scope of an engineering course.

Thus, interculturality refers to the interaction of people from different cultures and backgrounds. Besides, sometimes, natural difficulties concerning different languages and cultures, involves various ways of thinking, particular social rules, specific laws, amongst others. When there are significant differences between the cultures of two groups, interculturality should be addressed carefully.

On the other hand, it has been observed that the merging of different cultures induces social enrichment, fuels creativity and provides competitive advantage (i.e. via better communication and negotiation).

Therefore, it was decided that interculturality should be examined in more detail in the next stages.

3.4. The Seminar at UTC: issues and main results

UTC was commissioned to organize a joint seminar, on February 3rd – 5th, 2016, in Compiègne. The Brazilian group involved four faculty staff from UTFPR and one representative from the Paraná State Government. The UTC group was composed of ten faculty staff. Dr. Hughes Choplin was appointed as moderator and was responsible for guiding the work.

At the beginning, each participant was asked to report a referential intercultural situation. These were categorized in interpersonal and organizational issues.

Jacques Pateau Conference

To grasp a deeper understanding on the interculturality theme, Dr. Pateau gave a talk to the group with the title: Interculturel: Situations et Compétences. He reinforced the need to pay attention to virtual closeness, how to construct bridges over two cultures, the increasing demands for cooperation and the subtleties of the decision process, amongst others.

Working groups

Next, the participants were merged and split into small groups. The first task was to produce and describe in details two different referential situation focusing on interculturality. After the discussion, the moderator identified the following main points: the demands for adaptability and flexibility, the integration of intercultural issues on the management of an international project (life, work), the ability to communicate in other languages (apart from English) and to identify codes and the mastering of different IT resources. Following, another compostion of small groups was asked to formulate three suggestions on how intecultural issues could be addressed in a framework of development for five years.

Additonally, aiming at understanding the industry perspective over engineering education, Mr. Allan Tissier, Director of Automotive Plant in Curitiba-Brazil, gave a videoconference talk to the group. Also, three senior engineers working for a Truck Manufacturing Plant, Brazil, recorded on a video, their impressions over the engineers profile that Brazilian universities are delivering.

Main results

From the overall discussions, three possible scenarios were drawn to couple the issues discussed during the seminar.

SCENARIO I-Label. To create a 3i Certificate, that would be delivered to students who have followed a demanding package of courses and projects linked to 3i. *Pros*: i/ it is easy to implement in practice; ii/ the students and lectures can realise that it is a suitable and interesting approach. *Cons*: i/ the scenario can be seen as a strategy similar to what is already in course.

SCENARIO II-International Vocational Course. Vocational six-year programs where the students will spend fifty per cent of the last years in industry: two years in the country of origin of the students and two years in the country of the sister university (UTC or UTFPR). *Pros*: i/ strong emphasis on industrial practice; ii/ intercultural experience. *Cons*: i/ funding; ii/ a six years time span.

SCENARIO III-Novel Course. The idea is to structure a complete new engineering course oriented to 3i. A group of students will alternate between both countries. Common courses for groups of students of UTFPR and UTC can be performed in presencial or distancial form. The pedagogic approach should be coupled, with contents co-definition and joint projects co-developed. *Pros*: i/ 3i focused course structure; ii/ both universities involvment from the beginning. *Cons*: i/ funding; ii/ intercultural issues for contents definition.

UTFPR and UTC are aware that, independently of the scenario chosen, they must comply with regulations (either from university or from government). Additionally, the accreditation bodies shall be involved in the discussions.

3.5. The next steps

Apart from meetings via videoconference and exchanging further information, UTFPR will host a meeting, with the participation of UTC faculty staff. The three scenarios will be re-examined. This time, it is expected to discuss in more detail the influences of innovation and industry contexts in the envisaged structure of collaboration between both universities.

4. Closing remarks

In the 21st century the world is changing rapidly. Engineering as a profession and engineering courses must reinvent themselves to cope with these novel demands.

UTC and UTFPR have developed over the years a strong partnership. Both universities are aware that they have to move further in the way they collaborate. Innovation, industry and internationalization (interculturality) can form the core of a novel framework of cooperation between both universities.

The three scenarios deployed in this work have to be further discussed and matured. It is already a consensus that whichever is the path chosen, its implementation should occur as a pilot approach, to better understand its implications in practice.

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