Evolution of the Electrical and Computer Engineering (ECE) Department from a Pure-Teaching to a Research-Teaching Orientation; the case of the Tecnológico de Monterrey

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***Abstract*— The ECE department at the Instituto-Tecnológico-y-de-Estudios-Superiores-de-Monterrey has evolved from a pure-teaching to a research-teaching department during the last 30 years. This paper presents the highlights of this on-going process initiated in the late 1980´s and early 1990´s when the ECE faculty was just dedicated to teach graduate and undergraduate courses. During the transition, new PhD faculty arrived, the institutional mission was reviewed, the Research and Graduate Division (DGI) was consolidated, research chairs were created, multidisciplinary groups appeared, and alliances with industry and international top level universities were promoted. Top Level certifications and external evaluations for engineering programs were also consolidated. By the 2010´s the TEC´s evolution pointed towards: Patents, JCR publications, QS rankings, strategic university alliances, ethics and citizenship. This evolution was also ignited by the new vision statement that propels the following institutional values: innovation, global vision, team work, human sense and integrity/ethics. In parallel to this evolution, TEC´s international evaluations according to QS World University rankings went from >500 before 2000, to 238 in 2015. The ECE department has contributed to this effort in: high performance students, committed teaching/research faculty, quality lab facilities, industry/university opportunities to students, pos-doc positions, highly recognized academic leaders and external international alliances.**

***Index Terms*—Electrical and Computer Engineering, Engineering Education, Academic Administration, University Rankings, Teaching-Research Balance, Educational Model**

I. INTRODUCTION

The "Instituto Tecnológico y De Estudios Superiores de Monterrey" or ITESM or "Tecnológico de Monterrey" was created back in 1943 by Eugenio Garza Sada, who was an extraordinary visionary engineer [1]. One of his primary objectives was to provide high level engineering education to professionals who could understand the engineering process of typical industrial processes such as steel making and food/drink processes. This brand new Institute of Technology was originally a teaching oriented institution with high standards and excellent quality in engineering education. This vision has continued through the more than seventy years of existence and still "Monterrey Tech" has been regarded as a top engineering education university, not just in Mexico, but also in Latin America.

Even though the internal organizational structure of "Monterrey Tech" has change through the years, the essential organizational units where the faculty resides consists of academic departments with well-defined functions and objectives. The academic departments provide an individual governance, resource management, planning, evaluation, office spaces, specialized laboratory spaces, and the fundamental ingredient consisting of highly qualified human resources including professors, laboratory technicians and administrative personnel. The Electrical and Computer Engineering Department or ECE is one of the premier, long lasting, highly regarded engineering department at the School of Engineering and Information Technologies of Monterrey Tech. Between the 1980´s and 1990´s an important change in the essential functions of the ECE department was envisioned by the whole institution. In those years the fundamental operation of the department was just to teach graduate and undergraduate courses. In those decades, new PhD faculty arrived to the ECE department and there was a need for good professional development tracks for them to allow the institutional growth in terms of research and development activities. The mission of the institution was totally reviewed in 1995 and the institution was propelled towards 2005 having the research activity as an active ingredient for graduate students and new faculty [2, 3]. The evolution of the ECE department initiates with this vision and the objective of this article is to discuss some of the obstacles, strategies and specific actions performed in order to deploy this fundamental mandate from the Monterrey Tech Institution.

II. OVERVIEW OF THE ECE DEPARTMENT IN THE 1990S

The ECE department has always been privileged by an excellent group of professors in different specialized areas such as circuit theory, electronics, digital systems, robotics, power engineering, and telecommunications. In those years and with the creation of the DGI (Division of Graduate Studies and Research) new research faculty arrived to the Research Centers such as the Telecommunications Center. Three undergraduate programs were fundamentally attended by the ECE department in those years: Electronics and Communications Engineering (IEC), Electromechanical Engineering (IME), and Electronics Systems Engineering (ISE). Two graduate programs were fundamentally attended by the ECE department in those years: Master of Science in Electronics Engineering (MSE) and

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Master of Science in Electrical Engineering (MIE) . The professors were distributed in the following ways:

1. Faculty fully ascribed at the ECE department which fundamentally did not have an official research commitment.
2. Faculty fully ascribed at the CS (Computer Science) department which fundamentally did not have an official research commitment.
3. Research faculty ascribed at the Telecommunications Center (or other center such as Manufacturing) and ascribed to the ECE department, who had research and teaching commitments.
4. Part time faculty ascribed to the ECE department. They lectured in special schedules either, very early in the morning or late in the evening, to allow their primary working activities at local industries.

The full time faculty, either teaching oriented or research oriented, had three tracks of professional development: teaching professor, consulting professor and research professor. Even though there was no official contract or document that classified each professor into one of the mentioned avenues, the ECE department head knew in advance by virtue of their primary activities, the track every faculty was following at the time. Some professors had a hybrid professional development with activities in both, consulting and research. In addition, the ITESM system, particularly the Monterrey Campus, had a Classification Committee (similar to the "Tenure and Promotion Committee of American Universities") that revised the professional development of professors and classified them into the following ranks: Instructor, Assistant Professor, Associate Professor, and Full Professor.

The members of the Classification Committee were selected by the Faculty and they must be ranked as full professors. The guidelines to perform the classification of professors were based in a document that established the Rules and Normativity of Professor Classification. At that time the main and major indicators for the faculty classification were: student evaluation (based upon the student survey about the teaching performance by the professors), participation in the research or education congress organized by ITESM, faculty service inside ITESM, national/international publications and proceedings, up to date discipline training, and teaching-learning model training. Other items were considered but with less weight to impact the final decision. A very important weight was given to the first four indicators mentioned above and sometimes a professor which could not achieve certain percentile threshold in the student evaluation survey, took a while to succeed in passing from associate to full professorship. In other words the message was clear, if you did not demonstrate that you were a very good teacher, regardless of your scholarly work productivity, you could not reach the full professorship plateau.

A. New PhD Professors and Teaching Loads

Also, during the 1990´s a huge effort was made by the Academic administration to hire PhD professors. A faculty holding a PhD had a significant advantage and was promoted easily because his research track record that was propelled by the research activities performed during the dissertation development. During this period, 3 new PhD Professors were hired by the ECE department and another 3 professors, holding MS degrees, were given scholarships (either by CONACYT or a combination CONACYT-TECH) to perform their PhD at Foreign Universities in the US or Europe. It seems that the ECE department was really preparing a very explosive transition towards a stronger department with an additional fundamental pillar named research. We must stress the fact that the Rules and Normativity for faculty classification asked for time periods between different classification ranks. For instance, the assistant professor to reach the rank of associate professor required an average of 5 years since the time he/she was classified in the previous level. Also to be classified as full Professor, an associate Professor should stay an average of 6 years since the time of the latest classification. The committee had exceptions especially when professors arrived to Monterrey Tech with experience from other institutions. A thumb rule in the promotion (classification) committee was: "if a professor arriving to Monterrey Tech with certain number of years of experience in another university, then this experience counted one half for a classification evaluation" [4].

The teaching loads for fully ascribed at the ECE or CE departments were 4 undergraduate courses per semester. However, if a professor supervised a master´s thesis, one master´s student supervision was equivalent to ¼ of an undergraduate course. This means that a professor having a supervision of 4 master´s students could teach only 3 courses per semester. The teaching loads for research professors at the Telecommunications Center was 2 or 3 courses per semester depending upon the research projects in which he or she was participating. The planning of the undergraduate level courses was performed by the department chair and the graduate level courses by the program director of the graduate program (such as MSE). This planning required a good coordination between the department head and the graduate program directors in order to distribute the courses in a very organized fashion without leaving out both a fully ascribed department and a research professor from a research center. Also the course schedule needed to be carefully reviewed to provide options both to undergraduate and graduate students, observing the needs and requirements of all ECE faculty.

By far the most important problem for the ECE department chair was to consolidate the interests and the needs of the research faculty to the operating conditions of the graduate and undergraduate programs without leaving out anybody without a complete load. Some of the main functions were:

1. Make sure that the undergraduate courses were properly aligned to the sequence required by the students providing, whenever possible, different scheduling options.
2. Make sure that the graduate courses were offered and distributed during a 2 year period in order to provide a good variety of courses such that the students had a diversity of topics and support for their thesis research.
3. The course scheduling options must comply with the needs and requirements of students as well as to fit the requirements of professors, leaving spaces for faculty meetings.
4. To search for part-time professors who had experience with the course to be taught providing some liaison with real world industrial problems.

5. Provide operative working spaces, both offices and specialized labs, to faculty, graduate students, teaching assistants and research assistants.
6. To serve as a good bridge for the information dissemination from the dean of the school to the ECE faculty, both the research and teaching professors.
7. To perform the semester planning for all the fully ascribed faculty and the whole department.
8. To integrate different department committees to analyze initiatives to improve, manage or deploy specific strategies to enhance the teaching-learning processes.
9. To develop the full time faculty evaluation at the end of every semester.
10. To coordinate the formation and development of the national and international accreditation evaluation committees that performed the self-evaluation reports, visiting reports and responses to ABET [5] (Accreditation Board for Engineering and Technology), CACEI [6, 7] (Mexican National Accreditation Commission for Engineering Programs), SECAI [8] (System of Evaluation of the Engineering Teaching Quality in Latin America) and CONACYT [9] (National Science and Technology Council in Mexico, which is similar to the NSF in the USA) teams.

B. Teaching-Learning Educational Model

The teaching-learning educational model during those years evolved with the assistance of a technological platform such as Lotus Notes that allows a more exhaustive interaction between professor and students in the effort of trying to develop different educational strategies such as Problem Based Learning (PBL), Project Oriented Learning (POL), Collaborative Learning (CL) and other schemes.

The faculty was immersed in a special training called "Teaching Abilities Development Program" or PDHD (Spanish language acronym). Initially, this program was really enforced to full time faculty and just a few part timers took it. Also, the research professors did not take this program very seriously but later on, and with additional push from deans and department heads they started to consider the PDHD program as an important part of their teaching development at Monterrey Tech.

The initial reaction from students about the "new way to learn" or "new TEC teaching model" was very diverse. Some students were somehow disoriented due to the fact that much more proactivity from them was required and that the professors would be just facilitators of the teaching-learning process. Certain group of students were also inquiring about the role of the professor…the situation was: "we want the professor to lecture and explain the material as before". Other students took things very seriously and developed their work with excellence and much more neatness. Collaborative work increased and project oriented schemes were slowly embedded in many of the ECE junior-senior courses. This was in addition to the reformulation of the capstone integrative project courses, which usually were taken by engineering students at the end of sophomore, junior and senior years.

Some professors were skeptical and decided to wait a little longer to see the results of the new instructor role and the formal application of the educational strategies. Other professors were slowly integrating the educational strategies or at least the way they understood them in their courses. Most of the ECE courses used some of the easier and more reliable schemes to re-build their structure without reducing their contents, neither the exigency level. They included: educational intentions; objectives; analytical program; procedure, attitude and conceptual contents; bibliographical list; conceptual map; assessment hours; evaluation; project guidelines; and others.

The 1990´s marked a decade of fundamental changes in the Monterrey Tech educational model by making the student as the central core of the process. However, by no means the ECE courses were taught in radical fashion by applying pure POL, or PBL strategies. The faculty estimated that POL schemes adapted very well in applied engineering courses and when the POL scheme did not matched the way in which contents were organized, CL (collaborative learning) was used to promote more the focus on the student learning process. For basic engineering science courses such as electric circuits, basic electronics, electromagnetic fields, the faculty used more the CL strategy that complied much better with the conceptual course contents. Nevertheless, some engineering science courses required a final term project to apply the theoretical concepts.

C. External Engineering Certifications

In 1992, Monterrey Tech also initiated a very comprehensive program of engineering certifications with both, National and International Organizations. That year ABET was invited to perform accreditation of the engineering programs. During the 1990´s the CACEI was created in Mexico, following the experience gained by individuals participating in workshops and evaluations from ABET and SECAI organizations. In the 1990s, the SECAI, ABET and CACEI organizations certified the quality of the IEC and ISE programs and CONACYT certified the quality of the graduate programs MSE and MIE programs. During those years the ECE department did not attended a PhD program, even though there was an Informatics and Industrial Engineering doctoral program at Monterrey Tech. The development of the self-study activities, evaluation committees visits and evaluation committee's recommendations required a great deal of coordination and effort from deans, department chairs, undergraduate advisors, professors and administrative personnel at all levels.

The final remark about the 1990s is that most of the certification organizations that visited and reviewed the self-evaluation reports pointed out two major drawbacks that pertain to the ECE department and its infrastructure:

1. Heavy teaching loads for faculty.
2. Some of the teaching laboratories required much more investment in equipment.

Those recommendations were very important in the evolution of the ECE department both, to initiate the way to re-define the faculty teaching model at Monterrey Tech, and to comply in the way the campus capital equipment committees operated. The teaching loads ignited the tendency and intentions to support more the faculty using seed money to drive research initiatives inside the academic departments and research center. Therefore, the creation of the research chairs was an imminent action for the year 2000.

III. The ECE Department in the Early 2000s

The ECE department in the first decade of the 2000´s followed a diversification strategy to promote research areas that we did not have before. Health care instrumentation, integrated micro-devices, remote laboratories, power electronics and robotics were further reinforced by joint venture projects and strong personal interest from faculty. The DGI was now integrated to the school of Engineering and all the Research professors (from Telecommunications) integrated very well in the ECE department. The ECE department now attended the following new programs: Electronics Technology Engineering (ITE), Electromechanical Engineering) (IME), Biomedical Engineering (IMD), Mechatronics Engineering (IMT) and Information Technologies and Communications Engineering (ITIC). Three graduate programs were attended in those years: Master of Science in Electronics Engineering (MSE) and Master of Science in Energetic Engineering (MIE) and Doctorate Program in Technology and Communications DTC). The professors were distributed in the following ways:

1. Faculty fully ascribed at the ECE department which could have research, consulting or teaching fundamental orientation.
2. Part time faculty ascribed to the ECE department and with primary activities in Industry, business or other organizations. They also lectured in special schedules either, very early in the morning or late in the evening, to allow their primary working activities at local industries.

A. New Faculty Classification Structure

The unified approach for full time faculty generated much more team work among different groups inside the ECE department. An official document was generated to give the fundamental guidelines to perform faculty classification among: instructor, assistant, associate and full professorships. The Tecnológico de Monterrey continued with the integration of a well-structured Classification Committee as before, but now with a more strict guidelines in how to define the threshold levels for faculty performance and ranks inside the institution. In some way we were approaching the operation of a sort of "Tenure and Promotion Committee of Typical American University". In addition, this committee was now considering other activities that in the past were not accountable for the classification procedure. For example, publications in educational journals or conferences were very important in teaching oriented faculty. Therefore, in addition to the heavy teaching load, the teaching oriented faculty would require to present results of the learning processes developed in their students. Even, the Tecnológico de Monterrey gave special motivation to faculty that participated in the Educational Management Research Congress (CIGE) which is performed every year.

For faculty classification, now there were other important indicators and not only the student opinion generated by the exit surveys. Now there were six ingredients that were evaluated by the Classification Committee:

1. Teaching performance, based upon the student´s opinions.
2. Research performance, when available and depending upon the faculty profile.
3. Consulting performance, when available and depending upon the faculty profile.
4. Institutional participation.
5. Personal growth in the profession.
6. Participation in the community.

Even though the 6 elements of the faculty classification were considered in full detail, the message was still clear, if you did not demonstrate that you are a very good teacher and regardless of your scholarly work productivity, you could not reach the full professorship status.

During the first decade of the new century, the teaching loads for research faculty fully ascribed at the ECE department were adapted to consider professor involvement in project and thesis supervision. Still, a professor supervising of 2 master´s and 2 PhD students coming from particular funded research projects could have teaching loads of additional 2 courses. Also during this decade the research chairs were created at the Tecnológico de Monterrey. Research chairs consisted of:

1. A leading research faculty with a proposed field of study, preferably something that was a continuation of his/her dissertation research.
2. A team of one or several professors ascribed to the research group in order to support the proposed field of study.
3. A group of MS and/or PhD students collaborating in the field of study and developing their research projects in such a field.
4. The research chair could be linked to one or more academic departments and they were evaluated once a year in order to continue the support for seed money.

There was also a call for proposals in order to fund a selected group of research chairs. An evaluation committee was appointed in order to revise the merit of the proposal in order to obtain funding from 500,000 to 1.5 million Mexican pesos that provided seed money to attract other sources of financial support.

The teaching-learning educational model [10] continued to evolve towards learning strategies that contributed to the deployment of student activities such as project orientation, problem based development, cases methodology and collaborative endeavors. Early in the first decade of the 2000´s, the blackboard learning platform consolidated as the leading candidate for staying as the course management and interactive software to use in most of the courses taught at the Tecnológico de Monterrey. Some efforts were made in order to develop one platform from our own. This was called WebTEC, which provided an interesting interaction tool that was briefly used in some courses but later on dropped due to lack of stability and uniformity. At that time, a second generation of the "Teaching Abilities Development Program" or PDHD was continuing offered to professors.

B. Undergraduate and Graduate Programs Revision

In 2005, Monterrey Tech initiated a very comprehensive undergraduate program revision that changed the way those programs were presented to the high school students. After some focus groups strategies and making some market studies with employers and alumni, some of the undergraduate engineering program names were changed to make them easier to sell among the high school students. Particularly several

undergraduate programs attended by the ECE department changed as follows:

1. IEC – Electronics and Communications Engineering was changed to ITE or Electronics Technology Program with a minor in telecommunications. A further change (in 2007) was to have the ITM program or Telecommunications and Microelectronics Engineering program.
2. ISE – Electronics Systems Engineering was changed to ITE or Electronics Technology Program with a minor in robotics and embedded systems. A further change (in 2007) was to have the ISD program or Digital Systems and Robotics Engineering program.
3. IME – Electromechanical Engineering was left with the same name.
4. IMD – Biomedical Engineering was left with the same name.
5. IMT – Mechatronics Engineering was left with the same name.
6. ISC – Computational Systems Engineering was changed to ITC or Computational Technology Engineering program.
7. Other programs in information technologies such as ISI and LATI were changed also for ITIC or Information Technologies and Communications Engineering program that later on converged to the actual IT-Business program called INT or Business and Information Technologies Engineering (2007).

From this new strategy, in Monterrey campus, the ITM program was closed in 2012 and the ITE program was closed in 2013. After those changes, by 2014, the final result was that the main program directly supported by the ECE department was the ISD at undergraduate level. In graduate school the programs supported by the ECE department were:

1. MSE – Master of Science Degree in Electronics Engineering with two major emphasis: Telecommunications and Electronic Design.
2. MIE – Master of Science Degree in Energetic Engineering with the major in Electrical and Power Electronics Systems.
3. DTC – Doctorate in Information Technologies and Communications which was the umbrella for the following research areas: a) Informatics and Computer Science, b) Optics and Microsystems, c) Telecommunications and d) Power Electronics.

C. Multidisciplinary Groups and Alliances

Even though the undergraduate program activation and deactivation starting back in 2005 did not generate the expected results in acquiring more students interested in the big "E" for the old hat of the EE field, a new trend in forming multidisciplinary groups was followed by many ECE faculty. Also the graduate programs attended provided a more flexible way to connect people from different departments. Particularly the research chairs initiated during the first decade of 2000 produced many interdisciplinary connections that prevail until today. The following groups were formed with ECE faculty participation:

a. TEC-health with ECE faculty in the creation of biomedical instrumentation.
b. Biomedical faculty with ECE faculty in the teaching of undergraduate and graduate level courses.
c. Mechatronics faculty with ECE faculty in the teaching and research of multi-functional devices and systems particularly oriented towards robotics and control systems.
d. Chemical Sciences, Biotechnology with ECE faculty in the development of scientific summer and research topics for undergraduate and graduate students.

During the first decade of the 2000 the Tecnológico de Monterrey consolidated most of the external certifications and accreditations, both national and international. As we mentioned before ABET came back in the early 2000, CACEI continued the regular evaluations, now ITE and ITM, every 6 years during first decade of the 2000. The graduate programs were also accredited by CONACYT under the excellence PNP-C ("Padrón Nacional de Posgrado de Calidad") program group. The ECE department did attended the DTC program and several PhD students received their degree during the first decade of the year 2000.

In the 2000s an entrepreneurial support to undergraduate students was intensified to allow more spin-offs and the enhancement of the incubation of new business created and directed by senior or just-graduated students from many disciplines. The graduate school generated a very strong alliance with the INPI (National Institute of Intellectual Property, Mexico) in order to promote the generation of patents and intellectual property protection. The ECE department was part of this effort by participating in many intellectual property (IP) activities by patent generation and supporting spin-off activities both by graduate and undergraduate students.

A final comment here about the first decade of the year 2000 is the intensification of University-Industry alliances such as: TEC-FEMSA, TEC-Google, TEC-Microsoft, TEC- Siemens, TEC-Hewlett Packard, TEC-GE (General Electric), TEC-NI, TEC – Qualcomm, TEC- Toshiba, and TEC – Schlumberger.

The ECE department or some faculty was involved in certain way in most of those alliances mentioned. Much more joint venture groups were available through other academic departments at the Tecnológico de Monterrey. The fact that the ECE department was involved in the multidisciplinary projects, the creation of intellectual property (patents), generation of more publications through the DTC program and the creation of more join ventures with industry, deployed a very solid platform to provide enough impulse toward the fast pacing years beyond 2010.

IV. THE ECE DEPARTMENT BEYOND 2010

The Tecnológico de Monterrey in the second decade of the 2000, initiated a very important journey towards the better 50% of the 600 best Universities around the world according to the British QS rankings [11] for comprehensive academic institutions. The ECE department established their objectives and strategic plan around the vision statement developed: "We form leading individuals with entrepreneurial spirit, human sense and with international competitiveness" [12]. The basic institutional differentiators [12] were:

1. Top educational model focused to develop leading individuals with entrepreneurial spirit.
2. Institutional prestige.
3. Liaison with alumni, enterprises and institutions.

4. Formation with human sense.

To achieve the fundamental objectives the institution created the National Graduate School of Engineering and Science (EIC) that provided a very convenient organization forming the research and development platform that could create ideal conditions for research professors in the campus. The professors ascribed to the EIC [13] would have the following incentives.

1. Adequate teaching loads to permit their research endeavors.
2. Groups of interest according to their specialties and their research lines.
3. An economic stimulus from S.N.I. (national systems of researchers ...CONACYT) and an additional stimulus from the institution in order to incentive the innovation in terms of paper publications and intellectual property generation.
4. The possibility of inviting academic leaders around the world to integrate their groups of research.
5. The possibility of inviting and hiring Post Doc individuals to your interest groups to continue fresh research after finishing their dissertations.
6. Scholarships to graduate students at MS and PhD levels having a previous selection by exam presentation and interview with the admissions committee.
7. A performance evaluation based upon JCR publications, patents submissions, proposal writing, grant receiving (from both industry and government) and their maintenance in the S.N.I. according to the required evaluation frequency by CONACYT (the NSF of Mexico). This would constitute about 50% of their evaluation while the other 50% would come from their teaching performance both, at graduate and undergraduate level.
8. Adequate funding for travel to conference presentations, sabbatical stays, short stays at universities with joint venture research groups.
9. Adequate funding for specific equipment needs and matching funds when proposals are submitted to government or industrial consortiums.

Also, after 2010 the Tecnológico de Monterrey developed a very important strategy to hire distinguished academic leaders and some other very young research professors that had enough credentials to enter the S.N.I. Even though initially the administrative procedures were not synchronized correctly between the ECE department and the EIC, Post-Doc and Research Professor Positions were formalized and the ECE department established a very strong coordination with the EIC to jive the interest of the new research faculty with the Electrical Engineering needs. Three new research faculty and three post-docs were hired from 2013 through 2015 in order to enhance the research projects in telecommunications, BioMEMS and power electronics. From those positions, one new international post-doc and two new international professors collaborate now at the ECE department in a great effort to boost collectively the research and development in areas such as sensors, devices and telecommunications.

From 2010 thru 2015, the initiative of Ethics, Citizenship and Sustainable Development [14] was developed at the Tecnológico de Monterrey. Most of the ECE professors took a workshop about Ethics-Citizenship-Sustainable-Development (ECDS) such that they could include a course activity to their students about this important traversal area. For instance, the analysis of the IEEE ethics code or conduct code was developed by graduate and undergraduate students in some courses. This analysis was performed with the perspective of the complex individual citizenship schemes and the sustainable development triangle [15]. In addition, a strong emphasis was given to the multidisciplinary projects where students from engineering and non-engineering fields could participate in common projects involving design, analysis and product prototyping.

In 2014 the initiation of the INCmty [16] event gave a very comprehensive push to the entrepreneurial activities in the campus. In addition to the traditional courses and support to entrepreneurial students of different areas, the INCmty event provided them with key note speakers, workshops, project exposition, joint venture capital observations, industry participation and panel discussions. In 2015 the event was attended by more than 5000 people and it was developed not only in Monterrey campus but also at the Monterrey Convention Center. In this event, other showcases were performed such as “Conexión TEC” where many engineering related projects were shown to capture possible funding from angel investors.

During the 2010 decade a very important indicator for the advance in terms of worldwide position was the British QS rankings [11]. The figure 1 shows the progression in the rankings for the TEC since 2007. The figure shows that TEC´s international evaluations according to QS World University rankings [17] went from greater than 500 before 2000, to 433 in 2007, to 387 in 2010, to 320 in 2011, to 306 in 2012, to 279 in 2013, to 253 in 2014 and to 238 in 2015.

V. Results, three decades of continuous evolution

The figure 2 shows a brief summary of the evolution of the ECE department during the last three decades since 1990. During the last 30 years the ECE department has developed a deep transition that contributes to the institutional goals to meet the strategic objectives fulfilling our University vision [12]. The number of full time professors raised from 12 to 15 and to 20 in the 1990s, 2000s and 2010s decades, respectively. The major contributions delivered by the ECE department can be summarized as follows:

1. The growth of the ECE department in number of professors and the reduction of the overall teaching loads as shown in the figure 3.
2. The amplification of the spectrum of multidisciplinary research activities particularly in telecommunications, sensor and devices, power electronics, microsystems and energy.
3. The intensification of the research activities in terms of journal publications and conference proceedings as shown in the figure 4.
4. The increment of the submitted patents and as direct consequence the growth in granted patents. This is summarized by figure 5.
5. The negotiation of additional external alliances with Universities abroad, national/multinational companies, and joint venture with prestigious academic leaders. This growth is summarized in the figure 6.

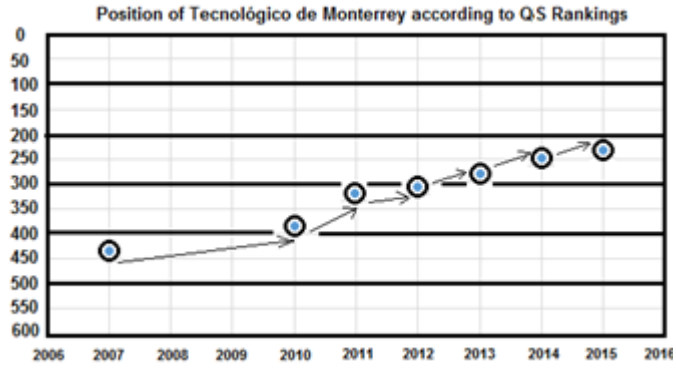

Fig. 1: Tecnológico de Monterrey rank according to the QS rankings [17].

The information presented in figures 4, 5 and 6 shows that considering just 5 years during the second decade of the XXI century, the research activity is reaching the levels obtained from 2000 thru 2009. Also, from 2010 to 2015, the intellectual property activity has already surpassed substantially the figures obtained from 2000 to 2009. Finally, the number of research alliances with Universities and joint ventures with academic leaders have doubled and tripled, respectively, from years 2010-2015 compared to years 2000-2009.

VI. Conclusion

The ECE department leaders who established the roots of the EE profession during the years early than 1990 deserve a recognition for their effort in consolidating the fundamental teaching strategy with an extraordinary excellence in education of EE professionals. During the 1990s the ECE faculty collected the teaching legacy and performed a very exhaustive refinement to this model having a high teaching loads and trying to initiate the route toward the transition for the new millennium. During the first decade of the new millennium a new group of collaborators, that included research professors in telecommunications and microsystems, initiated the ECE transition having an improved teaching loads, some primary research and intellectual products derived from their PhD dissertations, and incorporating new university alliances by developing joint ventures with academic leaders abroad. Finally during the years from 2010 to 2015 a boom in publications, joint ventures and intellectual property development have positioned the ECE department as a strong pillar in the Engineering School to achieve the results that situate the Tecnológico de Monterrey as a fast growing research institution that improved 149 positions (387 to 238, from 2010 to 2015, respectively) in the British QS worldwide rankings of comprehensive universities offering undergraduate and graduate programs.

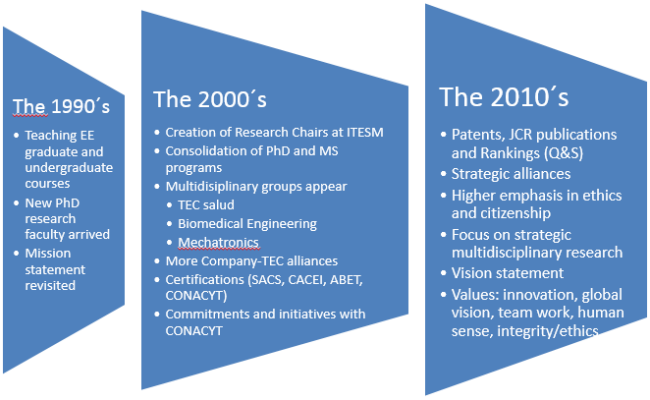

Fig. 2: Three decades of continuous evolution in strategic and operative initiatives for the ECE department [18].

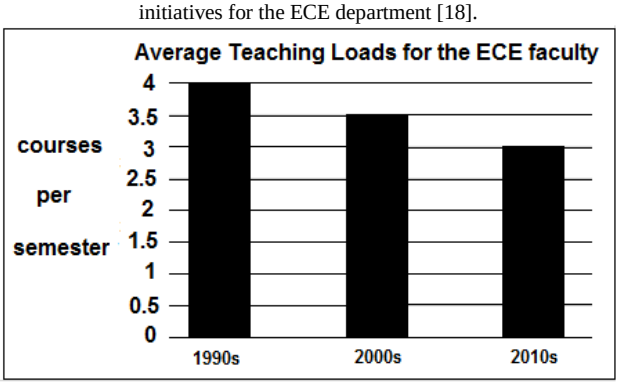

Fig. 3: Average teaching loads for ECE faculty. Includes research, consulting and teaching full time professors [19].

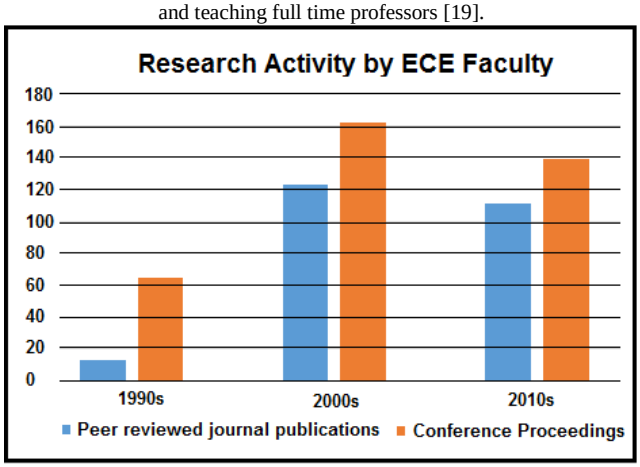

Fig. 4: Publications and Conference Proceedings by ECE faculty for the years 1990-1999, 2000-2009 and 2010-2015, respectively [20].

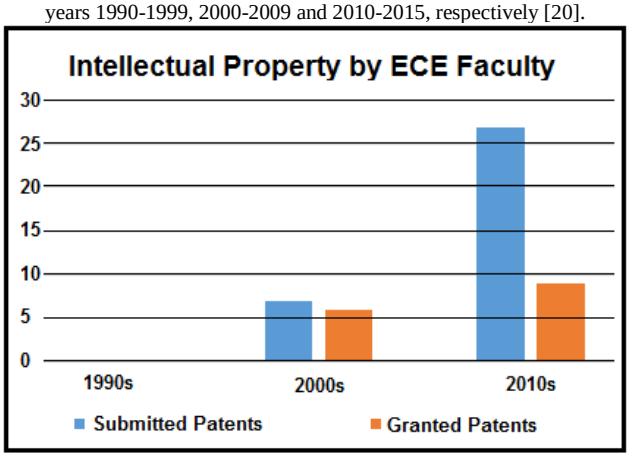

Fig. 5: Submitted and Granted Patents by ECE faculty for the years 1990-1999, 2000-2009 and 2010-2015, respectively [20].

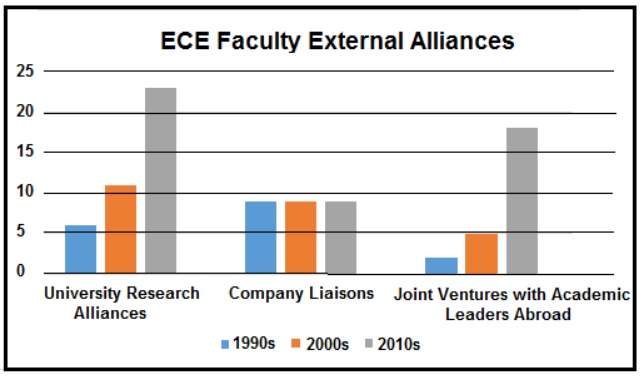

Fig. 6: External Alliances by ECE faculty for the years 1990-1999, 2000-2009 and 2010-2015, respectively [20].

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