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ELECTRICAL AND COMPUTER ENGINEERING PROGRAMS IN TWO COUNTRIES: A NEW PARADIGM FOR COOPERATION

Abstract

In the past, cooperation between faculty working in electrical and computer engineering (ECE) programs in the U.S. and those in the developing world has mainly involved the sharing of the strengths of U.S. programs with programs in the partner country. Some of these countries, like Brazil, have arrived on the world stage with many ECE faculty and programs functioning at levels similar to those in typical programs in the U.S. This new reality, combined with the new communications and computer technologies and the historical ramifications from the past, has generated a new paradigm for cooperation between programs in the US and those countries.

Introduction

Global standards have developed over the past half century to promote similarities in program content in both electrical and computer engineering. Electrical and computer engineering (ECE) education has experienced rapid growth all over Brazil. In one program, the number of graduate students (several hundred) is only slightly less than the number of daytime undergraduates while a significant evening program in ECE exists as well. The present quality of programs in Brazil allows its international partners to benefit both technically and pedagogically from collaborations involving both countries.

Programs in each country have to deal with the cultural and financial situations peculiar to each. Political and economic stability exists in both countries. There are differences to be sure, but engineering education is stable or growing in both countries. Programs in both countries face problems in assimilation of foreign faculty and graduate students into the mainstream of teaching and research. Institutions in Brazil have had active programs to promote proficiency in Portuguese. Students are admitted to engineering programs in Brazil by competitive examinations. At the best Brazilian universities, laboratory facilities are on a par with or better than those in some U.S. institutions.

Career paths for faculty might differ in both countries, but the goal of continuing growth in competence is the same. In Brazilian institutions the faculty career involves acquiring the master's and doctoral degrees and a formal procedure for progress through full professor by competitive examination. The established university in Brazil typically functions with greater self-governance than its American counterpart. Chairs, deans, and even the university president can be elected by a weighted average of votes from the institution's faculty, technical and administrative staff, and students.

The educational experience and technical expertise of Brazilian ECE faculty present many opportunities for ECE programs in the U.S. Brazil continues to be a rich source of Ph.D. students for the U.S. ECE programs in the U.S. and Europe continue to be logical options for

post-doctoral studies. However, many institutions such as the State University of Campinas (Unicamp) and the University of São Paulo (USP) are logical places for graduate study, post-doctoral study, and career experiences and options for U.S. students and faculty. A recent article in the *Chronicle of Higher Education* (Sept. 4, 2010) documents Brazilian efforts to enter into this arena.¹

Beginnings

There are certainly dozens of stories relating the ways ECE faculty members from the U.S. have made an impact on their counterparts in Brazil. We will confine this description to one that is well-known to the authors. After finishing his Ph.D. at Harvard, Donald K. Reynolds, an American, was hired by the Instituto Tecnológico de Aeronáutica (ITA, Aeronautical Institute of Technology) in Brazil shortly after its formation in 1950. For decades ITA has been one of the top engineering schools in Brazil. Hired for a two-year stay, Reynolds encouraged two young Brazilian instructors, Rubens A. Sigelmann and Attilio J. Giarola, to follow him to Seattle. Initially a professor at Seattle University, Reynolds moved to the University of Washington in the late 1950's. It was at Washington that Sigelmann and Giarola completed their Ph.D. degrees. Sigelmann remained at Washington and, as of this writing, is a professor emeritus living in Seattle. Nevertheless, Sigelmann has maintained an active involvement with Brazil. Giarola returned permanently to Brazil in 1975 after working for Boeing and Texas A&M University. David A. Rogers, an American, earned his Ph.D. at the University of Washington and went to Brazil in 1972. His interest in South America began when he was a child and heard stories in church of missionaries in that part of the world. Reynolds and Sigelmann were among his professors at Washington, and Reynolds served on his Ph.D. committee. Rogers responded to an ad in the *IEEE Spectrum* in 1972 and was hired as a result of a telephone interview. Giarola's return to Brazil in 1975 brought them together at Unicamp where they were involved in various research programs sponsored by the Brazilian national telecommunications company Telebras. Along with Rui F. Souza, a Brazilian with a Ph.D. from Cornell, they advised many master's and doctoral students in the 1970's, with Souza and Giarola continuing a fruitful production of advanced degrees and research long after Rogers returned to the U.S. in 1980. Max H. M. Costa did his master's degree at Unicamp during this period, with Rogers and Giarola as co-advisors, and then went to Stanford for his Ph.D. After working in research institutions in Brazil and the U.S., he eventually joined the ECE faculty at Unicamp.

There are some interesting observations that can be drawn from this story. The first is that the people mentioned above all had very different personalities. Reynolds is perhaps best remembered as gregarious and energetic. Certainly that had an impact on Giarola and Sigelmann's decisions to head for Seattle. But all were dedicated teachers who loved their students. There was (and is) a sense of collaboration. Each professor benefited from interaction with the other and each chose to find employment in what seemed to be the best opportunity at the time. The Americans felt that they were learning from the Brazilians just as much as one might expect the other way around. Already in the 1970's Rogers could see Unicamp as a peer of many American institutions. And, of course, today, Unicamp offers its Brazilian faculty members opportunities and challenges that are similar to those at an American institution.

Bonds of Professional Collaboration and Friendship

If we consider these individuals and their relationships, we can get some insight about the reality of the new paradigm. Reynolds certainly brought state-of-the-art knowledge to ITA when he arrived in 1952. However, he was received by a gifted, highly motivated student body. They could receive his knowledge and develop new results. Sigelmann and Giarola are good examples of the sort of individuals Reynolds encountered. Following Reynolds to the U.S., they brought their knowledge to a country that was in the midst of significant technological growth and that was ready to incorporate the contributions of the two. Certainly they continued to receive, but they developed as creators and researchers in their own right. In time the two went on separate paths, one to follow a typical American academic career in which he could be a link between his students and Brazil while the other would return to Brazil after almost two decades in the U.S. and be ready to bring the best ideas he found to his home country. With his broad experience he was able to use his acquired knowledge appropriately with his students and do research in the Brazilian environment. Rogers arrived at Unicamp in 1972 with a freshly minted Ph.D., taught in Portuguese, and adapted to local needs, teaching one graduate course and one undergraduate course every semester until 1980. With the arrival of Giarola in 1975, Rogers realized that he was benefitting more from his Brazilian academic environment and his association with Giarola than he ever could have imagined.

Out of this relationship many others have developed. Giarola's M.S. student Ivan Lima finished his Ph.D. at the University of Maryland and then joined Rogers at North Dakota State University in 2003. Now a tenured associate professor, Lima was the key leader of an international exchange program developed under the auspices of FIPSE and CAPES, agencies of the U.S. Department of Education and the Brazilian Ministry of Education, that led NDSU and Michigan Technological University (MTU) students to study at the Universidade Federal do Pará (UFPA) and Unicamp, while UFPA and Unicamp students studied at NDSU and MTU. Lima is spending the 2011 calendar year in Campinas as a post-doctoral visiting professor. Rogers' first Ph.D. student in the U.S., Robert M. Nelson, benefitted from Brazilian post-doctoral visiting professor Adaildo G. D'Assunção in the mid 1980's. D'Assunção had been a student of Giarola and Rogers earlier at Unicamp.

Others could tell parallel stories such as Orlando R. Baiocchi, who served as Rogers' department chair at NDSU in the 1990's. Coming from Brazil in the 1980's and working as an ECE professor and engineering college administrator in the U.S., he has worked to encourage international connections and collaborations. As part of his sabbatical leave next academic year, he will develop a new FIPSE-CAPES interchange program between the U.S. and Brazil, as well reactivate his research work on nonlinear propagation at Unicamp.

Some people describe the relationships in science and engineering mentioned above by using the concept of a family tree. Certainly a family tree structure could be used to describe the professional involvements of countless American and Brazilian engineering professors. But the relationship is more complex than that. As the years have gone by and people have worked together, the relationships have become less like a family tree and more like the partnerships formed between community organizations or those formed between sister cities.

The Seattle Sister Cities Web site describes this quite aptly:

The Seattle Sister Cities program opens doors to establishing meaningful and lasting global friendships, partnerships, and connections. As Nelson Mandela stated during his address to the UN General Assembly, “the reality can no longer be ignored that we live in an interdependent world which is bound together to a common destiny.” People-to-people relationships not only enhance our lives, but represent our best hope for peace and prosperity in the future. Sister Cities programs raise awareness of global issues, promote greater participation in international dialogue and exchange and, by doing so, build and strengthen bridges of mutual understanding and respect.²

We can certainly restate this concept in terms of international professional collaborations as follows: partnerships involving ECE faculty members open doors to establishing meaningful and lasting global collaboration, professional connections, and friendships. We can no longer ignore the fact that we live in an interdependent world which is bound together to a common destiny. ECE international partnerships not only enhance our lives, but represent our best hope for peace and professional progress in the future. These collaborations raise awareness of global issues, promote greater participation in projects of joint interest and build or strengthen bridges of mutual understanding and respect. All of this is nowadays facilitated by the new technologies of ubiquitous networks and computing devices that take information about anything everywhere.

Progress towards the New Brazilian Economy of the 21st Century

Graduate programs in electrical and computer engineering developed quickly in the 1970’s in many Brazilian universities. The programs at the University of Rio de Janeiro (COPPE) and Catholic University (PUC) in Rio, the Federal University of Campina Grande in the State of Paraíba, the University of Pernambuco in Recife, the University of Santa Catarina in Florianopolis, and the University of Brasilia are some of the examples. These programs received federal incentives from institutions like CAPES (Ministry of Education) and CNPq (Ministry of Science and Technology) and from governmental financial institutions (FINEP, BNDE, Sudene). State-owned (and here “state” means the federal, state, or city governments) companies that had the monopoly control of telecommunications (Telebras), energy (Eletrobras), and nuclear development (Nuclebras) started their own research centers with close collaboration with federal universities. In the State of Sao Paulo, where state universities have been established for many years, it was FAPESP (State Foundation to Support Research) that played a key role in the development of the new programs.

As a part of these efforts many Brazilian professors had the opportunity to get their doctoral degrees abroad, but American universities were not competitive in terms of cost: while a foreign graduate student would pay only about USD 400 a year for tuition in Great Britain or France, the cost in the U.S. would have been at least 25 times higher. Nevertheless, many Brazilian graduate students came to the U.S. for their doctorates. The 1970’s also marked the time of the so-called “Brazilian Economic Miracle”; although of short duration, it attracted back to Brazil many scientists and engineers who had moved to the United States in the previous decade. It also marked the transformation of the Brazilian universities into the “American Model”, with the departmental structure that is characteristic of the U.S. In summary, there were factors that limited and others that stimulated the cooperation between the two countries in the engineering fields.

In contrast, the 1980's are remembered as the “lost decade” for Brazil. The economic model of the time was based on the concept of “market reservation”, which aimed at protecting the internal market for local industries, sheltered against competition from international enterprises. This model proved to be a failure and left Brazilian industries behind the international scene. In the mid 1990's the situation started to change with privatization of many sectors, including telecommunications and electrical energy.

Brazil in the New Economy of the 21st Century

As noted above, the 1970's in Brazil were marked by significant investments in infrastructure. The two decades that followed saw less funding for basic development. This created a significant need for developing basic structure in various areas that has been a driver for this century's economic growth.

The opening of markets and the general wave of globalization has contributed to improve international competitiveness of Brazilian industries in many areas. Innovation in the private sector is still relatively limited, but there are tax incentives (25.5%) for private investments in R&D.⁴ The 21st century has consolidated economic growth through established macroeconomic measures and structural reforms.

Brazil has now a USD 2 trillion economy, concentrated in the agricultural, mining, manufacturing and service sectors. The Brazilian economy has been growing since macroeconomic stabilization measures were taken in the mid 1990's, coupled to structural reforms in trade and investment and product-market liberalization initiatives. There is a need for further macroeconomic and structural reforms to lift the economy's growth potential over the medium- to long-term. The challenges that remain include adjustments in the macroeconomic arena, increase of innovation in the private sector, and improvement of labor utilization.

The New Economy and the Universities

There is a significant need in Brazil for more degrees in the science and engineering areas. In 2007 these were 11% of all degrees awarded. There is also a need for more university and college level degrees, as only 11% of the population aged 25-64 are so qualified. On the other hand, the labor market has shown resilience, with 7.9% and 7.4% unemployment in 2008 and 2009, respectively.

In spite of the current positive indicators in Brazilian economy, investment in R&D is still mostly concentrated in universities and some national enterprises. For example, Unicamp has reached the mark of 730 patents deposited rivaling the number of patents of Petrobras, the Brazilian petroleum company.³ In 2008 the Brazilian gross domestic expenditure in R&D (GERD) was only 1.1% of its GDP, according to a study of the Organization for Economic Cooperation and Development – OECD, significantly lower than the average OECD relative gross domestic expenditure on R&D of 2.3%.⁴ Also reduced were private investments, characterized by a business expenditure in R&D (BERD) of 0.5% of the GDP.

On the positive side are the growing scientific production (12.2% annual increase in the 1998-2008 period), the high density of doctorates (like Russia, Brazil awards more doctorates than the OECD average), and the quality of university science and technology programs. Also noteworthy is the percentage (18%) of patents under the Patent Cooperation Treaty with foreign co-inventors, compared to the 7.7% OECD average, a robust indicator of international cooperation.

Brazil is now the eighth largest economic power in the world and the forecast is that it will move up to fifth place around 2015. Politically, it has moved from the conservative, autocratic, military government of the 1960's and 1970's to a progressive, socialist-inclined, democratic form of government. Paradoxically, the state-owned economic powerhouses have given way to private enterprises, mostly multinational corporations in the areas of energy, telecommunications and digital systems. Since those companies do not necessarily develop R&D efforts in Brazil, and there are not many state owned or native businesses in these areas, the focus of academic research has changed. In some ways, it has come back to the early 1950's when only fundamental, rather than applied research was fostered. But the extraordinary development of Brazilian engineering programs in the last four decades, combined with the robust economy, has opened new possibilities of cooperation.

Opportunities for Graduate Study and Faculty Exchanges

There are many opportunities for collaboration between ECE university programs in the U.S. and Brazil. The projects, as mentioned above, that are coordinated by CAPES and FIPSE are good examples. Many other efforts have been initiated between U.S. programs and Brazilian ECE programs at ITA, USP, COPPE (UFRJ), UFSC, PUC-Rio, Unicamp, and others. For example, since 2002 Unicamp has had a double-degree agreement in ECE with the University of New Mexico. USP and Unicamp can be cited as examples of Brazilian universities that are heavily involved in promoting international collaboration in various areas.

Several programs are now in place to promote such collaborations: (i) FIPSE-CAPES programs to foster student and faculty mobility, (ii) "sandwich" programs to allow Brazilian Ph.D. students to develop part of their research in the U.S. (and vice-versa), and (iii) a CAPES-Fulbright program for exchange of students from technical schools. Considerable resources have been allocated by Brazilian agencies to support these programs. Exchange visits between Brazilian and U.S. high-level authorities in science and education have taken place recently. The challenge is to define what kind of exchange is most adequate and beneficial to both countries, and how that choice or paradigm can be extended to international cooperation in general.

Unicamp's and COPPE's electrical engineering (EE) graduate programs have received top classification by CAPES.⁵ These and other outstanding schools have had their ECE undergraduate programs recommended as five-star programs by Abril Publisher's Student Guide.⁶ These are some indicators of the level of quality that is available in ECE among some Brazilian universities.

The efforts to establish a partnership program have been traditionally developed in a bottom-up fashion, by interested faculty members in the U.S. and Brazil. The D. K. Reynolds story included above indicates how one of such relationships has developed. However, cooperation is

still not systematic and not broad enough to be self-sustained. A new paradigm is needed that can take advantage of these historical bonds and, at same time, make use of the pervasive communications tools provided by the Internet and the institutional resources that are now in place at many institutions. Significant help can be obtained from the international relations offices that exist in most universities, like the Unicamp Office of Institutional and International Relations (CORI).⁷ But no new initiative will make an impact in either country, if it does not take into account that universities in the US and in countries like Brazil have strengths and challenges that are of the same order of magnitude, and that can vary dramatically from one specialty to another.

Conclusions

A new era of cooperation has arrived for ECE programs in Brazil and in the U.S. The programs, faculty, and students in both countries will be beneficiaries of the opportunities presented, as long as the factors described above – history, use of technology and acknowledgment of comparable competence – are taking into account: that is the new paradigm. The success of this model of cooperation between the American and Brazilian universities could be useful in developing similar programs worldwide. The authors and others are developing programs tailored to the interests of their institutions and based on this paradigm. Assessment of the outcomes of recent projects and the ones being developed is under way and will be analyzed in future papers.

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