

Research Institutionalization Efforts at the University of Puerto Rico – Mayagüez

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Abstract - In the last ten years, research activity at the University of Puerto Rico at Mayagüez (UPRM) has more than doubled, as seen by a variety of indicators. This increase in research activity has been possible due to sustained initiatives –timid at times, more aggressive lately– to institutionalize research efforts at the University. Although a fundamental milestone was set twenty years ago with the creation of the Research and Development Center (R&DC), more recent initiatives are currently coming to fruition. These include: (1) the anticipated creation of the Deanship for Research and Graduate Studies, (2) the implementation of a special Seed Money Fund for certain emerging areas (such as Bio-Engineering) in collaboration with UPRM's three biggest colleges (including Engineering), and (3) the initial steps to develop a Research Park. The above mentioned initiatives, together with the ongoing construction of a new state-of-the-art Bioprocesses Pilot Plant close to campus, collaboration efforts in all major disciplines, and a new paradigm based in continuous assessment, will ensure that the growth seen in the last ten years will sustain itself for decades to come.

Index Terms - Assessment, Biotechnology, Collaboration, Research

FROM COLUMBUS' ROUND WORLD TO FRIEDMAN'S FLAT

Puerto Rico (PR) is the smallest of the Greater Antilles, an island of less than 9,000 square kilometers and more than 4 million inhabitants. Discovered 515 years ago to the western civilization by Christopher Columbus (the person who proved to a disbelieving world that the earth was not flat), PR was a colony of Spain for just over 400 years. It passed to the United States (US) after the Cuban-Spanish-American War of 1898. The Commonwealth of Puerto Rico organized itself under a constitution in 1952 and, although still a US territory, has a high degree of local autonomy electing its own governor and legislature, and boasts one of the most stable political and economic environments in Latin America and the Caribbean.

Puerto Rico is 8 hours away from Madrid by air, 4 from New York, 2.5 from Miami, and 7 from Los Angeles, but only nanoseconds away by internet connection from

Singapore, Ireland, Turkey or Brazil. The first internet cable in the Caribbean connected our University to the US mainland over 20 years ago. Only Jamaica (39%) in the Greater Antilles, and in South America only Argentina (26%) and Chile (43%), have higher internet penetration rates than Puerto Rico (25%).

The island's main "products" are: knowledge, technology, pharmaceuticals, and entertainment. Some examples to illustrate this are the following:

Knowledge [1]:

- With 0.4 patents per thousand million (B for billion, for the purpose of this paper) dollars of its gross national product (GNP), PR is 35th in the list of the 130 countries registering patents in the US. The first are: Taiwan (18.4), Israel (8.8), Japan (8.1) and the US (7.2). Of Latin America and the Caribbean only Bahamas has a higher rate than PR.
- The knowledge-intensive based services (KIBS) sector represented over \$5B in 2002 revenues; of this, engineering services was the most important subsector with \$558M in revenues and 4,859 employees.
- According to the Bureau of Labor Statistics, in 2000 49% of the labor force of PR and the US had a post-secondary education (with PR somewhat higher). In 2005 this had risen to 51%. In 2000, of the G-7 countries only Canada had a higher rate at 51%.
- Approximately 33% of PR's labor force is occupied in the knowledge economy, ranking below the US (47%), but above South Korea (18%) and roughly at the same level with Singapore and Japan (36%).
- Slightly over half (54%) of PR's GNP corresponds to the KBI sector. Similar rates are observed in the US and European Union (EU).
- Over 16% of our University graduates are hired by US companies.

Technology [1] [2]:

- Thirty-seven percent of PR's 2005 exports were advanced technology products (ATPs). This exports rate was only surpassed by Singapore (59%) and Malaysia (55%), and ranking above Ireland (34%),

Korea (33%), Hong Kong (32%), US (32%), China (30%) and Japan (24%).

- The trade balance in ATPs for PR is positive: exports are 59% higher than imports (in the US, the trade balance is negative, by 20%).
- Fifty percent of all US-built pacemakers are manufactured in PR.
- The city of Humacao is the only place in the world where Microsoft makes its new Windows Vista system.
- PR is 18th on the list of biggest medical and scientific equipment exporters.

Pharmaceuticals [2] [3]:

- Twenty-five percent of all the world's medicines are produced in PR.
- The pharmaceutical sector alone generates 24% of our GNP.

Entertainment/Tourism:

- The headquarters of rum-giant Bacardí are in Cataño, a 15-minute boat-ride from the capital city of San Juan.
- Recently inaugurated in 2005, PR's state-of-the art Convention Center is the largest in the Caribbean and the most technologically advanced in Latin America and the Caribbean.
- PR's newly inaugurated PR Coliseum has recently been classified as a world leader in musical concert attendance and revenues, winner of the much-coveted International Large Venue of the Year in the 2006 Pollstar Concert Industry Awards.
- PR is proudly represented in the music scene by world-renowned artists including:
 - J Lo and the *salsero* Marc Anthony
 - Daddy Yankee, with his "A mí me gusta la gasolina" and reggaeton
 - Chelo, who made his "Cha, Cha" world-famous in last year's Miss Universe pageant
 - Ricky Martin "Livin' la vida loca"

The western port city of Mayagüez is the third most important in Puerto Rico, and the farthest away (but just an easy 2.5-hour drive) from San Juan. It is a central hub of very active tourism and home of our campus, one that has evolved as the primary economic motor of the region. In 2010 the city is set to host the 21st Central American and Caribbean Sports Games, the oldest regional games in the world. For this reason, there is an active agenda to improve existing infrastructure, such as the maritime port, two airports and the conversion of the San Juan-Mayagüez southern route to an expressway.

UPR-MAYAGÜEZ: A BRIEF HISTORY [6]

The University of Puerto Rico at Mayagüez (UPRM) is a mid-size, public, land-grant institution, consisting of four

colleges – Agricultural Sciences, Arts and Sciences, Business Administration, and Engineering – and three administrative/service deanships – Academic Affairs, Administrative Affairs, and Student Affairs. The Agricultural Experiment Station (AES), the Agricultural Extension Service, and the Research and Development Center (R&DC) are integral parts of the institution. The Mayagüez campus has around 12,000 students (including 1,100 graduate students), just over 1,000 faculty and 1,800 administrative personnel. Approximately 1,800 students graduate yearly, including (in 2006) 208 Master's and 12 PhD students. Out of a total operating budget of \$230M, 15% is allotted to externally-funded research, education and service projects.

When UPRM was founded in 1911, as the *Colegio de Agricultura y Artes Mecánicas*, only one other higher learning institution existed: our sister campus at Rio Piedras, established only 8 years before, to specialize in the preparation of much-needed teachers. From the beginning the *Colegio* concentrated its efforts in preparing professionals in the technical fields of Agriculture and Engineering. Research focused on Puerto Rico's agrarian economy, with emphasis placed on sugar cane production, the island's main product during the first half of the 20th century.

In the 1950s Puerto Rico's economy shifted from one based in agriculture to manufacturing. Our engineers, instead of becoming master distillers/chemists, began operating factories. The slogan coined for this change was "Operation Bootstrap" (in Spanish it was known as *Operación Manos a la Obra*, literally "Operation Hands to Work"). Today, PR is engaged in another economic paradigm shift, this time to a knowledge-based economy: *Operación Mentes a la Obra* (literally "Operation Minds to Work"). One of the main driving forces of this paradigm change initiative is Biotechnology, and the University is central to this development. As such, Puerto Rico has recently been referred to as the Bio-Island. And UPRM aspires to become a Bio-Campus, more of which is discussed below.

RESEARCH AND GRADUATE STUDIES AT UPRM

Research activity began at our institution a long time ago, since it was, and continues to be, an essential part of our mission. In the beginning, most of this research focused on the agricultural sciences, particularly through the AES. After the 1950s, through the creation of the Natural Sciences programs, efforts in recruiting excellent faculty and students paid-off. In the early 1970s UPRM established its first PhD program in Marine Sciences. Our Department of Marine Sciences, with facilities both on campus and off campus at the island of Magueyes (off-shore from the fishing village of La Parguera in southwest PR) is a leader in research areas such as corals, algae, reefs, etc. The Department also developed a strong educational program, Sea Grant, funded by the National Oceanic and Atmospheric Administration (NOAA). It has graduated an average of around 5 Master's and 5 PhD students a year in the last years.

For twenty years the only doctoral program in Mayagüez was in Marine Sciences. However, since the early 1990's, extraordinary developments have occurred in both research and graduate programs, as can be seen by the following indicators:

- Four new PhD programs: Civil Engineering, Computational and Information Science Engineering, Chemical Engineering and Applied Chemistry
- At least one PhD program in the pipeline: Tropical Agriculture
- More than 150 doctoral students
- 32 Master's programs with over 900 students
- Over 30% of the graduate students are international students from 30 countries representing all continents except Australia (and Antarctica).
- Since 2004, the amount of money for graduate assistantships paid from external funds has surpassed that paid by institutional funds.

In order to foster further improvements in the research agenda of the University, an array of strategically-designed institutional efforts is being taken upon. Some of these efforts, with particular attention to Engineering, and Engineering-related fields, are outlined below.

RESEARCH IN THE ENGINEERING PROGRAMS [7]

The UPRM School of Engineering has evolved into a top-notch regional institution of engineering education. All its undergraduate programs are accredited by ABET. As per ASEE's 2005 Profiles of Engineering and Engineering Technology Colleges, the School ranks as follows in the US:

- 30th in the number of Engineering bachelor degrees awarded
- 6th in the number of bachelor degrees awarded to women
- 8th in industrial and chemical engineering degrees awarded
- 11th in civil engineering degrees awarded
- 16th in electrical engineering degrees awarded
- 32nd in mechanical and computer engineering degrees awarded

The largest of UPRM's four colleges in terms of students, it accounts for 39% of the institution's enrollment, with approximately 4,900, 35% of which are women. Its academic offer consists of seven BS degrees and 14 graduate degrees.

Currently, 85% of the engineering students take non-traditional courses, referred to also as alternate learning experiences, to complement their theoretical preparation. These include the following three variations: Engineering Practice for Co-Op Students, Special Topics, and Undergraduate Research. For example, 52% of the 2006 class participated in the Cooperative Program, which provides professional practice to students in their related

fields. One which merits a special mention is the Model Factory, a high-tech manufacturing activity run by students who must attend an interdisciplinary course that covers surface-mount technology (SMT) process and material basics; in the Factory graduate and undergraduate students from multiple courses can participate in projects, allowing the operation to experience continuous improvement.

Another of the non-traditional options, and the one we want to emphasize here, involves active research. During the last two decades the College of Engineering has evolved to have a balanced portfolio with a strong research component. Over 400 graduate students and 1,000 undergraduate students participate in R&D projects every year. All departments have a course, with the uniform code 4998 (e.g. INEL 4998 for Electrical Engineering), Undergraduate Research, in which students participate in a research project under the supervision of a faculty member acting as an investigator. During the 2006-2007 Spring Semester, 185 students were registered in the 4998 courses. An additional 63 undergraduate students were working in a research project.

DEANSHIP OF RESEARCH AND GRADUATE STUDIES [4]

In 1986 the UPR Board of Trustees established the Research and Development Center (R&DC) at Mayagüez to facilitate the administration of science and engineering research projects. Nevertheless, it was not fully operational until its first director was appointed in 1994. Since then, the growth in academic potential in research and other areas can be surmised from the growth evidenced by the following indicators:

- The number of proposals submitted duplicated in the first 5 years of operation, with an average yearly growth rate of over 9% in a decade.
- The amount of external funds almost tripled in the first 6 years, with an average yearly growth rate of almost 22%.
- There has been a 23% average yearly increase in federal funds received by our faculty.
- NSF, NOAA and NIH have increased their respective funding levels by 32.3%, 54.8% and 68.2% since last year.

Currently, each of the four colleges has an Associate Dean for Research and Graduate Studies. These officials serve as liaisons between their faculty and the institutional administration in several capacities, including serving on committees and recommending proposals for evaluation, submission and funding.

Last year the Director of the R&DC and the Director of the Graduate Studies Office submitted a revised version of a previously dormant proposal to merge both units into a fourth institutional Deanship for Research and Graduate Studies. The proposal contemplates the coordination of efforts to promote graduate studies and research outside of

UPRM, to institutionalize assessment of graduate programs and research projects, to improve administrative efficiency, and to elevate the current Carnegie classification of UPRM from Master's/L to Doctorate granting, among other goals. The proposal was unanimously endorsed by R&DC Board of Trustees in October 2006, and is awaiting the evaluation by the Academic Senate.

SPECIAL SEED MONEY FUND

A portion of the indirect costs recovered by the University is re-invested in research efforts through seed money (SM) grants given by the colleges and the R&DC. Typically SM grants are very small (around \$5,000) and are awarded to individuals. In FY 2008 a decision was reached to establish a campus-wide SM program funded by the three largest colleges (Engineering, Arts and Sciences and Agricultural Sciences), the R&DC and the Chancellor's Office. Instead of, or in addition to, running three or four smaller SM programs as described above (each of whose total funding vary from \$30,000 to \$90,000 and are distributed among tens of individuals), these four units will contribute a total amount of approximately \$350,000. This will permit that at least one, perhaps up to five, bigger projects will be funded.

The Call for Proposals, which will be made public during the summer, is contemplating the following minimum requirements for these proposals:

- Collaboration: Must involve two or more departments or two or more colleges.
- Partnership: Must have at least one industrial partner.
- Students: Must include at least one Research Assistantship.
- Prospects for Future Funding: Must support the design phase of a project to be submitted to a funding agency, particularly the PR Research Trust Fund Initiative.

For FY 2008, it was decided to focus on Bio Science and Bio Engineering, which is compatible with the PR government's Bio Island initiative. The Bio Science and Engineering 2008 SM fund will cover three main areas:

- Biotechnology
 - Bio Informatics
 - Bio Medical Sciences (possibly in collaboration with the UPR Comprehensive Cancer Center)
- Bio Engineering
 - Bio Remediation
 - Computational Biology
- Agriculture Biotechnology
 - Food Technology
 - Molecular Sciences (possibly in collaboration with the new UPR Molecular Sciences Building)

A BIO-CAMPUS IN THE BIO-ISLAND: THE BIOPROCESSES PILOT PLANT

PR is the Bio-Island, considered 5th in the Biotech industry in the world. Recently \$3.2B was invested in medical applications by five companies: Amgen, Abbott, Lilly, Ortho and Becton-Dickinson. Sixteen of the 20 Biotech and biopharma blockbusters are produced in PR. Agricultural biotech companies such as Monsanto, Pioneer Hybrid, Mycogen, Syngenta and Rice-Tech are also present in the island.

In the early 1990s UPRM started an undergraduate program in Industrial Biotechnology (IB), an interdisciplinary program with strong components in Biology and Chemistry (around 30 credits each), Mathematics (18 credits) and Engineering (24 credits). The program's main Engineering partner is Chemical Engineering. This program has become one of the most solicited by incoming freshmen, and today has the highest Admission Index in the UPR system.

Several years ago, the IB program submitted a white paper to the Biotechnology Cluster of PR, a conglomerate of industry, government and academia, regarding the need to establish a pilot plant. The proposal was approved by the Cluster and the PR Industrial Development Company (PRIDCO) commissioned a feasibility study to Pharma Bio Source in 2004. The study indicated that establishing a facility to address monoclonal antibody technology would increase PR's competitiveness in attracting biotech business. A 30,000-ft² building was commissioned using \$5M committed by the University, \$5M committed by PRIDCO and \$2.5M committed through a grant from the Economic Development Agency. Construction began last November (2006) and is expected to be finished in November of this year. PRIDCO allotted another \$3.5M to equip the facilities, which will be divided in two separate areas of roughly equal footage: one for training and the other for research. The goal is to promote corporate-sponsored research and training. A non-profit corporation was created to run the Plant. This corporation is governed by a Board of Directors with representatives from the three sectors, and is already administered by an Executive Director. The Chancellor and the Director of the IB program are two of the BOD members, maintaining close ties with UPRM.

The facilities, located at an industrial park 5 minutes away from UPRM, will particularly address the need to train professionals in the Biotech industry. As a result of a massive 2002 expansion of Amgen in Puerto Rico, UPRM developed a 2000-ft² IB Learning Center and inaugurated it with a two-month, 240-hour long, training course for Amgen's employees. Since then, as other biotech plants established or expanded in Puerto Rico, the demand for training has significantly increased. By adding the Pilot Plant wing, training capacity will increase by 850%. Examples of biotech plants in PR are:

- Abbott (in Barceloneta, an hour away from Mayagüez) received FDA approval in March 2006 to manufacture the active ingredient of Humira, its drug for rheumatoid arthritis with highest sales volume in the world (\$2B in 2006). Abbott invested around \$400M in a plant newly-inaugurated in April 2007 (the largest in PR), and is awaiting approval from the EU regulatory body.
- Amgen has invested over \$2B. The plant is a bulk-manufacturer, formulating and fill-and-finishing various drugs, including Neupogen/Neulasta (white globule generation), and Epogen and Aranesp (anemia treatment for cancer patients).
- Eli Lilly biotech operations in Carolina are the company's largest and most modern in the world. This investment surpassed \$1.2B. Humalog, the first fast-action insulin drug on the market, is manufactured here.
- Ortho Biologics LLC (in Manatí, close to Barceloneta) manufactures Eprex, a biotech-derived hormone used to treat anemia in cancer and HIV+ patients.

Research at the Pilot Plant will address microbial fermentation and mammalian cell culture and will emphasize process development and improvements commissioned by industry. It will certainly serve UPRM faculty, who will be called upon, as needed, to perform research at its facilities, depending on their areas of expertise. It could also serve the IB students as a laboratory, since the program includes courses such as BIND 4905 (Practice in IB) and BIND 5005 (Project in IB) to promote extracurricular experience.

TOWARDS A RESEARCH PARK

The construction of the Bioprocesses Pilot Plant, as well as the ever-growing need for university research space, has increased our desire and determination for developing a research park. The PR government recently announced its intentions to develop its first research park, the Knowledge Corridor, in metropolitan San Juan. This Corridor will be accessible by metro, and will interconnect the UPR-Rio Piedras and Medical Sciences Campuses, its Botanical Garden, the Molecular Sciences building, the Medical Center complex, and other private universities.

At Mayagüez we are considering several initial options to develop our own research park. These include:

- Possible expansion in the Industrial Park where the Bioprocesses Pilot Plant is being built.
- Ten-year lease of a big pharmaceutical company's facilities in Mayagüez.
- Lease of 1 to 5 buildings left unoccupied by another pharmaceutical company in Aguadilla, a half-hour drive from campus. The 19,000-sq² R&D Building has 15 completely functional and equipped work benches.

All three options, as well as others that may appear, focus on the need of research and development space and equipment in several disciplines, including Engineering. Local R&D activity should promote the establishment of new business. However, one major drawback so far is that an anchor tenant for a research park has not been identified. Therefore, an existing partnership between the University, industry and government known as PR-TEC (the Puerto Rico Techno-Economic Corridor) is being explored as an avenue to establish contacts with future tenants.

COLLABORATION AND CONTINUOUS ASSESSMENT [5]

The common factor in the above-mentioned initiatives is collaboration. Cooperation is crucial to curricular development, as is the case of the Industrial Biotechnology program; in major research projects, as with the Special Seed Money Fund (where inter-departmental collaboration is a major ingredient); in establishing partnerships with government and industry, as with the Bioprocesses Pilot Plant; or with any of the Research Park initiatives currently under consideration. The co-operative actions of many are paramount in efforts like these.

As part of this collaboration strategy, the R&DC is establishing contacts and ties with several organizations with goals common to UPRM. Several of these organizations are: the National Council of University Research Administrators (NCURA), the Association of University Research Parks (AURP), the National Association of State Universities and Land Grant Colleges (NASLGC), the Associations of University Technology Managers (AUTM), and the International Association of Science Parks (IASP).

Finally, it is important to mention that UPRM has embarked in an initiative to institutionalize the culture of evaluation using continuous assessment. NCURA, one of the groups mentioned above, has started an initiative to create an assessment rubric for research administration, and a protocol for peer review. The Research and Development Center of the University of Puerto Rico – Mayagüez is paying close attention to these efforts.

With this in mind, several initiatives are beginning to take place from the research institutionalization perspective. As mentioned above, the proposal to create the Deanship for Research and Graduate Studies includes, as one of its core objectives, to conduct assessment of its graduate programs. Moreover, since the R&DC acts as an administrative umbrella for many research projects, it could act as a catalytic agent to promote assessment of those activities. In order to do this, we are beginning to do continuous assessment of the services performed at our own offices.

A simple example of this is an e-mail-based clientele satisfaction questionnaire we conduct at our External Resources Office (ORE, in Spanish). After a proposal's budget is initially revised by ORE, or a proposal is submitted to an external source, the Principal Investigator (PI) receives

an e-mail with three simple questions, and a fourth item asking them to make additional comments, if they so wish. This effort was started in February of this year, and results have been very positive:

- 90% of the initial budget revisions are done in less than 24 hours
- 77% of the proposals are reviewed and submitted in 3 days or less
- 100% of the PI's surveyed agree that the transaction was completed satisfactorily
- 100% of the PI's surveyed agree that the transaction was completed in a reasonable time
- 100% of the PI's surveyed agree that the service received by the ORE staff are satisfactory

Other offices of the R&DC will begin conducting the same survey during the coming year. This and other tools will help us gauge the response of our main customers, and will allow the institution to anticipate and conform to the strategic direction that research is taking at UPRM.

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