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VOLUME XLVI, NUMBER 2 FALL 2015

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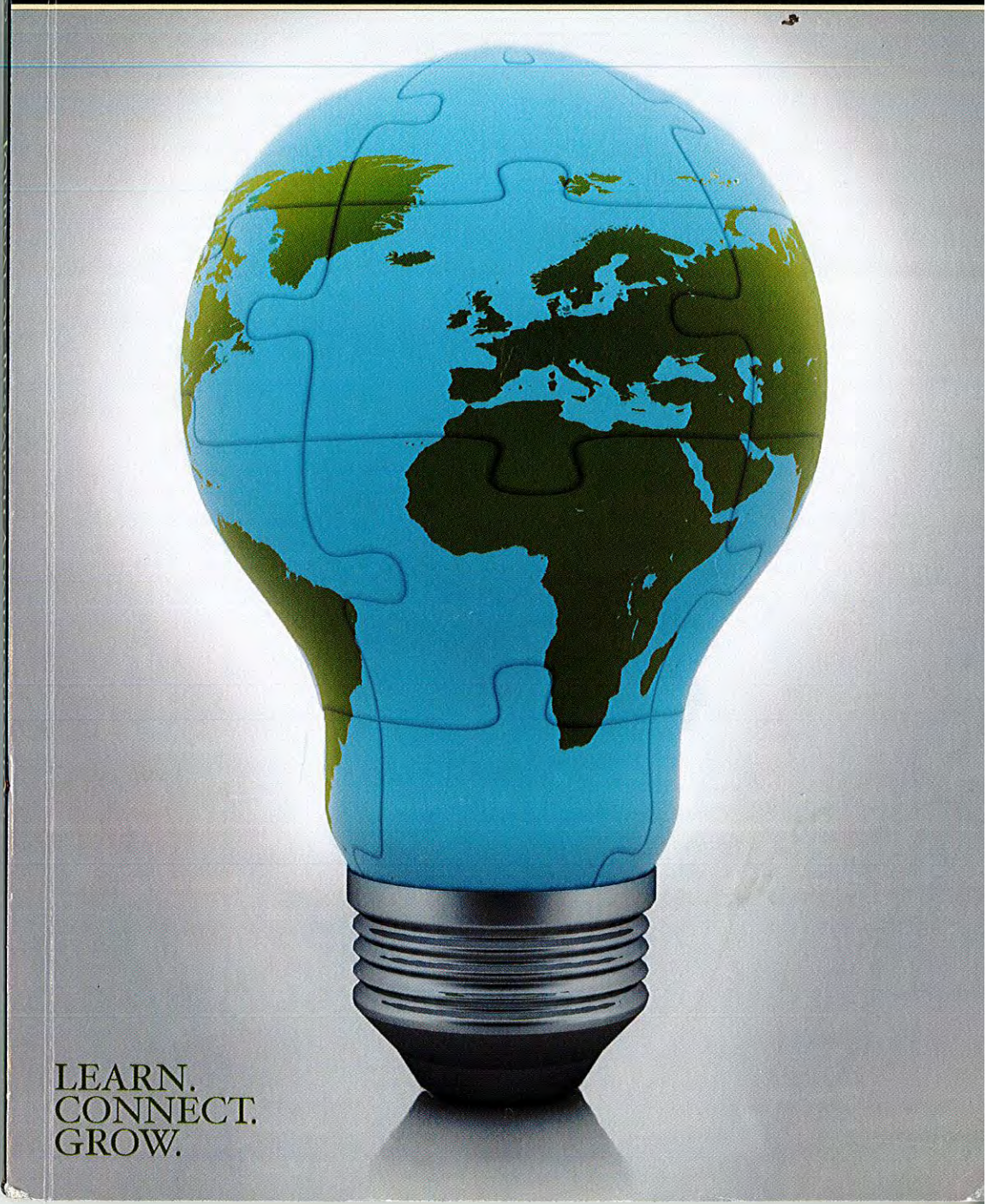

Prepared by Graphic Arts and Publishing Services
at The Henry M. Jackson Foundation
for the Advancement of Military Medicine, Inc.

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240-694-2032

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Growing Faculty Research for Students' Success: Best Practices of a Research Institute at a Minority-Serving Undergraduate Institution

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Abstract: *Broader diversity in the research workforce affords the inclusion of research agendas, methods, and perspectives that might otherwise be overlooked to address key social and scientific problems. However, promoting diversity in science is not a trivial matter. It entails mitigating some of the long-term social and institutional inequalities that have prevented the participation of underrepresented groups, such as Latinos, in scientific research. For instance, the Hispanic Association of Colleges and Universities (HACU) reports that Hispanic serving institutions receive (on average) only 69 cents for every federal dollar of funding that all other higher education institutions receive.*

This article describes how an interdisciplinary research institute at an under-resourced Hispanic serving institution managed to build a culture of undergraduate research by promoting the research of local faculty and supporting their mentoring role in the face of economic and administrative challenges. In spite of dramatic budget cuts that fluctuated between 1.4% and 13.3% (2005-2013) and loss of 23% of its senior faculty due to retirement (2006-2014), during a 10-year period, the Institute of Interdisciplinary Research (IIR) at the University of Puerto Rico at Cayey was able to increase the number of faculty conducting research from 7 to 54 and the number of students engaged in research from 8 to 481. During the period, UPR-C faculty from the Sciences, Arts, and Business Administration engaged in

the applied, regional and interdisciplinary research mission of the IIR, published 81 peer-reviewed articles, offered 238 research presentations, and submitted 81 grants (57 to external funding agencies and 24 to UPR-C divisions). Grant approval for external funding was 45.6%. Students' most important research products included oral and written presentations in epidemiology, psychology, anthropology, ecology, chemistry, microbiology, pedagogy, business administration, and humanities. Overall, during the period, 84% of students who applied to graduate programs were admitted. This article identifies the key approaches and outcomes of a strategic planning process that allowed the IIR to become a successful campus-wide research resource for interdisciplinary research at an undergraduate, Hispanic serving institution facing fiscal and administrative challenges.

Keywords: *institute of interdisciplinary research, research management, Hispanic serving undergraduate institution, undergraduate research, undergraduate faculty, research and mentoring, Puerto Rico*

Introduction

Puerto Rico was a colony of Spain for ~400 years until 1898, when the US occupied the Island. Transformations ushered in by World War II changed the overtly colonial relationship between the Island and the US to the current Commonwealth status as a non-incorporated US territory. Island-born Puerto Ricans are US citizens and most wish to maintain close political and economic ties to the US. However, most Puerto Ricans also view themselves as a distinct group with common history, culture, and heritage (Dávila, 1997; Duany, 2002; Morris, 1995). Both Spanish and English are official languages in Puerto Rico, but mainly Spanish is spoken. Because the Island's economy is heavily dependent on US industry and federal funds transfers, mainland events such as the recent economic recession adversely affected this US territory. Currently, Puerto Rico's per capita income is ~$15,200 (half that of Mississippi, the poorest state), and the unemployment rate is 15.4 percent (Alvarez, 2014). The resident population is estimated at 3.6 million (U.S. Census Bureau, 2013), while almost 5 million Puerto Ricans are now living in the US (U.S. Census Bureau, 2011).

Since 1903, the University of Puerto Rico (UPR) has been the sole public institution charged with the mission to "develop the latent intellectual and spiritual enrichment of our society fully," so that "the intellectual and spiritual values of exceptional personalities that surge from all its social sectors, *especially from those less favored in terms of economic resources,* will be put to the service of the Puerto Rican community" (UPRRC EGCTI, 2015, our emphasis). With a total student population of 61,967 students, the UPR system has to implement this mission across its eleven campuses: three of which are graduate and eight of which are primarily undergraduate. The University of Puerto Rico at Cayey (UPR-C) is one of the UPR's eight undergraduate campuses. It offers 27 bachelor's degrees in Natural Science (Biology, Chemistry, Mathematics and the Natural Sciences General Program); Social Sciences (Psychology and Mental Health); Arts (English, Literature, Humanities, Foreign Languages, Literature and Linguistics) and Professional Schools (Education and Business Administration). Enrollment trends from 2005 to 2009 varied from 22% to 33% in Natural Sciences, including the Natural Sciences General Program, 24% to 27% in Business Administration and from 13% to 14% in Social Sciences. General fall enrollment

at UPR-C has increased 5.39% from 3,634 in 2005-06 to 3,830 in 2009-10. Practically all students (99%) are Puerto Rican (UPR-C Assessment Office, 2013a, 2013b; U.S. Department of Education, 2012) and the majority (67%) is female. Most UPR-C students come from the municipalities that surround the town of Cayey, located in the central mountainous area of Puerto Rico (see Figure 1).

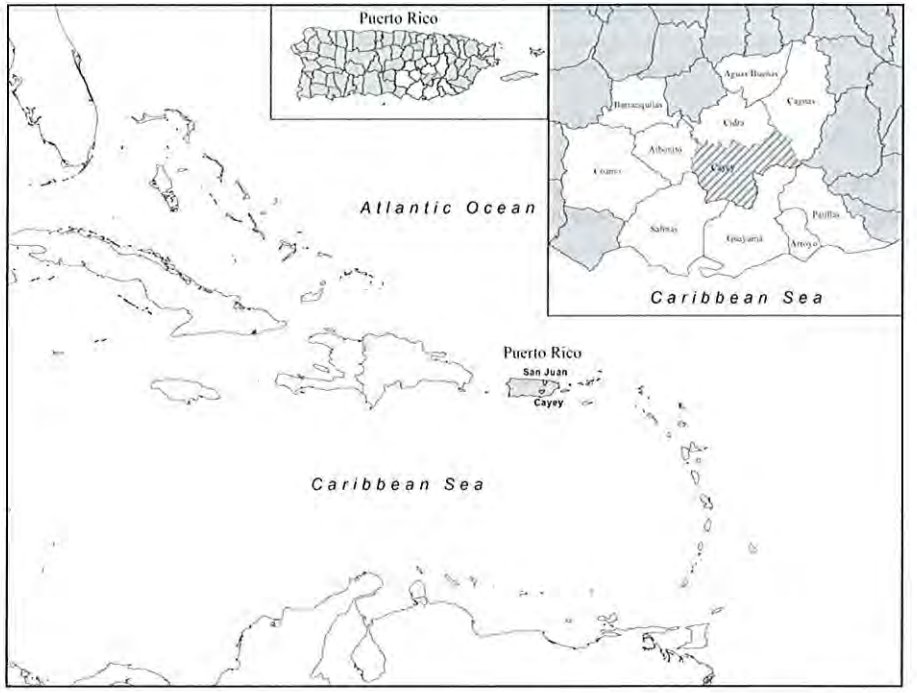

Figure 1. UPR - C catchment area and geographical profile

Consistent with UPR's overall mission, UPR-C offers quality educational opportunities to low-income students of its service region who meet the University's admissions criteria. The majority of incoming UPR-C full-time undergraduate students (75%) received Pell Grants and more than half (56.9 %) proceed from public schools. The average GPA for incoming freshmen is 2.87. Full-time attendance status in 2013 was 93%. The campus has 164 full-time faculty and 32 part-time professors, 90% of whom are Puerto Rican. One hundred twenty-nine are tenured or tenure-track, and 67 are faculty with non-tenure adjunct positions; approximately 79% of all tenure and tenure-track faculty have a Ph.D.

This faculty along with administrators and staff are charged with fulfilling three UPR-C missions, which together emphasize providing a quality education that integrates: 1) interdisciplinary approaches, 2) research, and 3) community engagement (UPR-C mission, 2006). The Institute of Interdisciplinary Research (IIR) (http://web1.oss.cayey.upr.edu/iii/) supports this mission.

Six overarching aims developed in 2004 guide the IIR initiatives: 1) to promote interdisciplinary research; 2) to produce knowledge that is relevant to Puerto Rico and to the UPR-C service region; 3) to facilitate research at UPR-C; 4) to promote research-informed curricular innovations; 5) to provide a supportive environment for researchers and students; and 6) to disseminate results of the research projects it sponsors. Unlike research centers at other colleges and universities that respond to particular faculties or academic divisions, the IIR operates under the general aegis of the Academic Deanship, supporting projects across all academic departments, programs and disciplines. Its six aims are broad enough to allow full participation from students and faculty from the natural and social sciences, business administration, education, and humanities, but not so broad that it loses focus on the applied, interdisciplinary and regional criteria of the research activities and projects it sponsors.

The IIR offers an array of research support services that respond to this broad mission. For example, it provides population statistics and census data support services to students, faculty and the surrounding community through its Census Information Center (CIC): an office supported via a memorandum of understanding between the UPR-C and the U.S. Census Bureau. Unlike other undergraduate research initiatives at UPR-C, the IIR offers these and other support services to students, while also promoting the academic and professional development for all interested faculty via workshops, the dissemination of local training opportunities, and the coordination of an interdisciplinary seminar series with invited speakers and local faculty. The IIR also offers pre- and post-award administrative support to faculty-led research projects in interdisciplinary areas of pertinence to the University's service region. Faculty from any academic departments can become affiliated to the IIR and seek such support. In general, faculty affiliated to the IIR develops projects that share a thematic focus in health and health disparities, education, social inequality, race and racism, and the environment. Supported faculty, in turn, recruit students as research assistants into their projects and the IIR coordinates activities to support the student's academic and professional development as well. Activities offered by the IIR to students include interdisciplinary courses, training on research methodologies and research ethics, workshops that prepare them for graduate school, among other academic enrichment activities. Furthermore, because the IIR offers administrative support to a variety of faculty-led research projects, undergraduate students come to the IIR headquarters seeking research opportunities and sometimes contact faculty directly when they learn about a project that aims to solve a specific, recognized problem of their interest. Finally, the IIR contributes to scholarship in various applied areas through the systematic dissemination of findings, via technical reports, peer review publications, and the coordination of a campus wide symposia where participating faculty and students are expected to present.

The IIR developed this ambitious undertaking as UPR-C was beginning a transformation from a predominantly teaching institution to an institution where scholarly research could also be valued. Like other undergraduate minority-serving institutions, faculty's ability to do research at UPR-C was compromised by lack of research infrastructure, institutional research policies and high teaching and service loads (Pickens, 2010). The regular course load at UPR-C for example, is 4 courses per semester and some faculty offer additional courses (ranging from 5 to 7 courses per semester) to meet departmental needs. Faculty must also participate in committee

work and perform administrative duties that can become quite burdensome in the context of fiscal shortages and reduced administrative assistance. Furthermore, mentoring undergraduate students at institutions where there are no graduate programs adds additional challenges since mentors cannot rely on the help of post-docs or graduate research assistants. Since undergraduate students do not have the expertise for much of scholarly work, faculty must go out of their way to train and design projects suited for students' participation. The development of the IIR thus required institutional transformations to ensure that faculty could have the time, incentives, institutional support and recognition necessary to develop their research and capacity to mentor undergraduate students.

To achieve such transformations, institutions must establish conditions (policies, incentive programs, facilities, administrative support, etc.) that promote those outcomes (Barthell, Chen, Endicott, Hughes, Radke, Simmons, & Wilson, 2013; CUR & Hensel, 2012; Pickens, 2010; Rabionet, Santiago, & Zorrilla, 2009; Tinto, 2012). Yet, these institutional changes take time and, at UPR-C, they were further complicated by extensive budget cuts, the drastic loss of tenured faculty and administrative turnover. In the course of 8 years (2005-2013), UPR-C experienced budget reductions that fluctuated between 1.4% and 13.3%, lost 23% of its regular faculty, and had five different Chancellors and six Academic Deans. There were also four different Directors overseeing developments at the IIR, with some administrations being more supportive of research than others. This article describes how the IIR was able to withstand these challenges and develop a culture of undergraduate research by promoting faculty participation in research and sustaining their research and mentoring practices at the UPR-C.

Best practices to support undergraduate research

Engaging faculty mentors as active stakeholders

While large research universities have, over time, developed the research infrastructure, policies, and administrative support necessary to run undergraduate research programs, undergraduate minority-serving institutions often do not have such infrastructure in place (Carpi & Lents, 2013, B30). Thus, before UPR-C could insure successful implementation of research mentoring practices, the IIR had to catalyze new policies, administrative procedures and institutional innovations that could promote research in the first place. For example, IIR staff had to develop administrative procedures not available before, such as: 1) fiscal procedures that allow students to receive compensation and insurance coverage during research field trips; 2) protocols to compensate research participants; 3) a shadow accounting system to support faculty in the monitoring and use of their project's funds; 4) the establishment of six performance databases to assist in the metric monitoring and assessment of the IIR efforts in different areas (faculty publications, presentations and proposals, seminars, workshops, conferences, pre- and post-award training, and a Students Follow Up Survey database) and 5) staff evaluation procedures and instruments suitable to assess their implementation of the IIR activities and services. Other internal fiscal and administrative follow-up procedures such documentation and payments tracking systems between administrative units were also implemented.

Most importantly, IIR researchers actively participated in drafting by-laws at the Academic Senate for the recruitment of faculty with research potential at UPR-C that made the selection of new faculty a more rigorous process while also ensuring that UPR-C disseminates positions widely to attract the best talent (UPR-C, Cert. #36, 2012). In addition, since 2008 Chancellors and Academic Departments began to consistently introduce contract letters into the hiring process to establish research as a tenure requirement. Furthermore, Certification #34 (2014-2015) of the Administrative Board allows faculty to receive up to 65% of the equivalent salary cost of their devoted time in an external funded project, as a research incentive.

Another important innovation was the establishment of joint- tenure-track appointments between the IIR and two Academic Departments (Biology in 2008 and Business Administration in 2013). Faculty hired under these innovative appointments allocates 50% of time to research activities and 50% to teach the equivalent of 6 credit-hours, instead of having a 12 credits course load. These two joint positions were supported by academic leaders at UPR-C and by the Vice Presidency of Research at the University of Puerto Rico Central Administration as part of an overall effort to promote research at this undergraduate campus.

The development of these new policies and procedures at the IIR took place in the context of administrative turnover and great fiscal instability. Setting these transformations in motion, thus required an "effort from below" (not a top-down approach) which meant engaging faculty, not just as research mentors but also as stakeholders who must actively mobilize to create the supportive environment they need for developing their research. Such active engagement from stakeholders—what Barthell et al. (2013, p. 42) call "building support"—early on in strategic planning is key for the sustainability of undergraduate research programs (see also Pickens, 2010) and this was the case of the IIR. In fact, the IIR's mission was conceived in 2003-2004 after five strategic planning sessions with more than 25 participating faculty representing all the academic departments at UPR-C discussing the strengths, weaknesses, opportunities, and threats of this institutional initiative (a planning technique known as SWOT analysis). This broad participatory process actively engaged faculty while also maintaining open channels of communication and firm commitment from middle management towards the interdisciplinary vision of the IIR.

Early developments at the IIR also benefitted from an institutional plan and leadership that had identified interdisciplinary education as a key area of interest at UPR-C since the nineties. The model developed for the implementation of General Education at the UPR-C shortly afterwards required that all first year students take an interdisciplinary course "that significantly relates two or more disciplines with the purpose of integrating or coordinating its concepts, methods, or conclusions" (UPR-C, Cert. #16, 1992). Similarly, the IIR's programmatic agenda privileges approaches that significantly relate two or more disciplines with the purpose of integrating or complementing concepts, methods, and analyses to generate new knowledge. Researchers can explore hypotheses in the fields and test them experimentally or conduct systematic applied investigation within a specific context to solve an identified problem in that context. Because of UPR-C previous trajectory with interdisciplinary curricula, faculty felt encouraged to work beyond their departmental boundaries in research projects as well. The idea of establishing the IIR thus developed in 2000 by a group of professors in the Social Science Department, as part of this institutional dialogue on interdisciplinary studies in research and education.

Upper level administrators committed to this vision in 2004 opened a tenure-track appointment for Social Scientists with scholarly publications and grantsmanship expertise. The first author, a cultural anthropologist, was recruited and designated as a full-time researcher charged with overseeing the IIR strategic development as a campus-wide resource. Later, UPR-C administrators added a full-time administrative assistant to the IIR regular staff. However, administrative positions, while important, were not enough to grow an interdisciplinary culture or research from which undergraduates could benefit. The question of how to achieve this status was thus amply discussed in strategic planning sessions where faculty members from different disciplines participated over the course of the 2003-2004 academic year, until they reached a common vision. At the initial stage of the process, a few participants favored the idea of focusing the IIR resources on supporting undergraduate students' research projects; while others believed more emphasis should first be placed on supporting and developing faculty research. After debate and deliberations based on the SWOT analysis, the majority of participants established an important consensus: before undergraduate research could flourish, the University and the IIR needed to support the research endeavors of faculty who could then effectively mentor students. This early understanding was fundamental for implementing most of the initiatives mentioned in the following sections.

Supporting local mentors

Mentors are critical for developing student talent and research competencies (MacLachlan, 2012; Serrano-García, 2006). However, efforts to support research and mentoring activities at undergraduate minority-serving institutions where faculty have a heavy course load and administrative commitments are multi-dimensional require a great deal of coordination and funding. Central strategies implemented by the IIR to promote faculty research were: 1) providing release time for faculty; 2) facilitating administrative support; 3) developing mentoring communities; and 4) combining accountability with recognition.

The first strategy—providing release time for faculty—is costly but critical for institutions such as UPR-C. Thanks to external funds provided by a Research Infrastructure for Minority Institutions (RIMI) grant from NIH in 2004, the IIR was able to provide four faculty members with 25% to 50% release time during a period of five years (2004-2009). The grant, which sought to build research capacity in predominantly minority-serving academic institutions, also had the goal of developing a biomedical and socio-behavioral interdisciplinary research program with an emphasis on health disparities. The research topics included race and racism, ethnopharmacology and pharmacognosy, gender and HIV, and nanomaterials for biomedicine. A group of five faculty members (three from the natural sciences and two from the social sciences) sought the grant and submitted the application for it with the assistance of the UPR-C External Resource Office. Three of the five faculty members who wrote the grant proposal actively participated in the IIR strategic planning process. With this 4.4 million dollar grant (the largest grant the University had ever received) faculty were able to teach two or three courses per semester (instead of four). This sustained effort enabled them to significantly strengthen their research agenda and mentor students effectively over the course of five years. The great majority (84%) of those students who participated and applied were accepted into and subsequently enrolled in 108 diverse graduate

programs in: clinical psychology, medical sciences, chemistry, mathematics, public health, pharmacy, professional schools, and biological and social sciences. With such positive results, UPR-C continued to provide release time and seed funding for other promising researchers with institutional funds. In 2006, UPR-C doubled the amount of seed funding allocated for the support of faculty research from $30,000 to $60,000.

Providing faculty with administrative support is also crucial, especially in heavily bureaucratic environments such as the public university. In 2010, the IIR won another five-year grant from NIH entitled " Building Research Infrastructure and Capacity" (BRIC Program, 2013). With this second NIH grant, the IIR was able to hire additional post-award personnel who could support faculty on the administrative front as well as train existing personnel in research administration and compliance. Without such support, faculty at under-resourced institutions can easily get discouraged from doing research and mentoring since they may end up dealing more with paper-work and the administrative hurdles of implementing a research project in a non-research institution and less with the research and mentoring as they ought. Recruiting and training excellent administrative and research support staff, who were often sought out by other units and departments for guidance, became a hallmark of the IIR that motivated faculty to pursue their research and mentoring activities.

Furthermore, to counteract burdensome workload of faculty, the IIR provided the support of mentoring communities. With this model, students who worked as research assistants with faculty had a variety of resources at the IIR that complemented and reinforced the guidance they received from their local mentors. Some of these include workshops and guidance for the development of an academic and research portfolio with their CV, personal statements, summer internship research applications, technical support for the design and development of poster presentations, graduate programs fairs, and meetings with peers to receive support, awareness and references about research strategies and commitment to pursue graduate studies, among other topics. This approach differs from the one-on-one mentoring model usually provided by research-intensive institutions. Rabionet et al. (2009) reported benefits of using such a multifaceted mentoring model based on multi-institutional collaborations at the UPR Graduate School of Public Health. Windham, Stevermer, & Anthes (2004) also reported that student interaction with a team of multiple mentors resulted in exposure to multiple perspectives and increased one-on-one interaction (p. 27). With NIH support, the IIR hired a training coordinator who worked in close collaboration with faculty mentors, a student development core leader, and other campus officials in the implementation of an Academic and Professional Development (APD) Program for undergraduates. The training coordinator provided one-on-one orientation to students who wished to learn more about research opportunities, internships and fellowships, helped them with their application and APD portfolio, organized a research speaker's series and identified a variety of resources for graduate school. Other strategies used to complement faculty mentoring included providing workshops on topics such as ethics in research, how to write a statement of purpose, how to write a CV, creating electronic student profiles, how to apply to summer research internships, and how to write a research question. The training coordinator and the student development core leader also planned an undergraduate research symposium, the publication of a student newsletter on research topics, facilitated students' access to international

and local virtual mentors from diverse research fields, and developed guides and workshops with the collaboration of the IIR staff to help faculty and research assistants improve their mentoring experience. All of these resources were published on the IIR webpage and updated bi-monthly for the benefit of students and mentors. These and other collaborative strategies implemented by the IIR with external and institutional funding distributed the responsibilities of mentoring among many individuals, allowing UPR-C overburdened faculty to concentrate on what they did best: providing students with the research experience, technical competencies and scientific guidance they need to enter graduate school.

Finally, the IIR combined faculty accountability with recognition. For many years (since the early 1990's to 2008) the peer-review system by which faculty members at UPR-C were evaluated did not seriously consider research productivity as a key tenure and promotion criterion. Although this changed after 2008 for pre-tenured faculty, post-tenured faculty were still rewarded primarily for teaching effectiveness and committee work and were, thus, less likely to feel motivated to invest time in developing and carrying out a research project. To counteract this hurdle, the IIR promoted faculty accountability through individual assessment activities that also facilitated the institutional recognition of their achievements. Research faculty were asked to submit a personal development plan (PDP) describing future research activities, plans for publications and presentations, submitting grants and students to be mentored. Faculty accompanied their PDP with a request to the IIR for training support, for sponsorship of external guest speakers who could be potential research collaborators, for contracting professional services (editors, evaluators, etc.) and other requests in support of their scholarship. At the end of each academic year, faculty submitted the annual report showing their achievements in relationship to the PDP. This information was then included in annual reports to the Academic Dean, Chancellors, posted on the IIR website and published in the IIR newsletter, *Encuentros*. In addition, faculty were invited to present their research progress during the UPR-C Faculty Development Symposia, a one-day activity dedicated to faculty research at UPR-C which is held once a year when no classes are in session.

Increasing and diversifying the pool of mentors

The aforementioned initiatives, while important, only managed to benefit a handful of researchers during the first seven years of the IIR's development (2004-2011). In order to mentor more students and provide more research experiences, the pool of local mentors had to be increased.

Two initiatives played a key role in achieving this goal. First of all, in 2011, the IIR created the interdisciplinary semester-long course for research assistants, Interdisciplinary Research Experience for Students (INTD 4116). The course allows any UPR-C full-time student, freshman through senior, to obtain credit for collaborating in the research project of a faculty member under his or her guidance. This course not only increased, but also significantly diversified the pool of mentors who could enroll students as research assistants, while also allowing students to receive credit for their participation, an opportunity not previously available to students from the Social Sciences, Education, Business or Humanities at UPR-C. The course is approved by the IIR's interdisciplinary Advisory Board, is evaluated as a pass/fail course, has flexible credits and is open to faculty from all departments who have no course-overload and can present a detailed

research plan. Although similar courses were available in the Chemistry, Mathematics and Biology departments previously, the new IIR course significantly increased the amount of mentors and students from other departments who could benefit from this opportunity, especially those from the Social Sciences.

Although the INTD 4116 course allowed the IIR to diversify the pool of faculty who could mentor students, greater efforts were still needed to increase the total number of mentors with research credentials. Like many other institutions of higher education, UPR-C had been experiencing a drastic loss of regular faculty due to retirement (Dehn, 2012). Not all retired faculty could be replaced with tenure-track positions, and the number of adjunct faculty grew from 26.8% in 2005-06 to 34.1% in 2012-13. However, since most of the faculty who retired were not active researchers, UPR-C managed to increase its local capacity for mentoring students in research by promoting hiring practices that established peer-review publication, grant development and undergraduate mentoring as a tenure requirement for the open positions at UPR-C. In fact, UPR-C is the only undergraduate campus in the UPR system that has consistently promoted the recruitment of research-oriented faculty in all academic disciplines and programs, following procedures outlined in policies developed by the Academic Senate (2004, 2012 and 2015). As a result, all 11 tenure-track faculty positions filled between 2011 and 2013 were hired with contract letters that established research expectations for tenure at UPR-C were in the Biology (1), Chemistry (1), Mathematics (2), Business Administration (1), Social Sciences (2), Education (2), Humanities (1), and English (1) departments. Some of the areas of interdisciplinary research of these faculty include: biomathematics and epidemiology, material sciences, clinical psychology, cultural studies, and labor economics. Many of these faculty were also guaranteed favorable working conditions in their contract letters such as: a) no course overload (i.e. not exceeding 12 credits per semester); b) no more than two course preparations per semester; c) no committee work overload; d) favorable class time arrangements that provide uninterrupted time blocks for research; and e) 25% release time for one or two semesters, among other support mechanisms. The contract letters of these new hires emphasized excellence in teaching, research, and student mentoring as important criteria for obtaining tenure.

These strategies and transformations, spearheaded by the IIR and a broad base of research affiliates, allowed UPR-C to increase the availability, engagement, and support of faculty who could devote time to research and student mentoring.

Increasing research capacity at the home institution

Although it is unlikely that any one strategy would have produced the successful results with undergraduates outlined herein, all the aforementioned actions have one key factor in common: they sought to promote the research capacity locally at UPR-C. In an environment like Puerto Rico, where students and faculty from underrepresented backgrounds are the majority, this strategy provides a critical mass of local mentors that—with adequate support—serve as excellent role models for undergraduates at their home institution.

This approach differs from traditional models of undergraduate training at predominantly teaching institutions, which often send students to conduct summer training with faculty at

research-intensive institutions, leaving the research infrastructure at the students' local institution relatively untapped. Research on the impact of this strategy on health professions has shown that such interventions are less effective than interventions that are sustained throughout college (U.S. Department of Health and Human Services, 2009). For Puerto Rico this export model further implies that knowledge production is better carried out elsewhere, reinforcing the current population exodus from the Island and stereotypes that Latinos are less intelligent. In contrast, the IIR staff and researchers believed that the students' home institution should develop its own research infrastructure by supporting and promoting the research of local UPR-C faculty in collaboration with research partners at other institutions of higher education in PR and in the US mainland. Such collaborations were fostered by inviting external speakers to the IIR interdisciplinary seminar series and by supporting faculty travel and presentations at international conferences with institutional and external funding. Supporting the participation of local faculty in summer trainings and internships abroad also encouraged collaborations between UPR-C faculty and faculty from other institutions. Through these strategies and by hiring and providing favorable working conditions for local Puerto Rican faculty invested in research, the IIR was able to expand the pool of mentors who could offer semester-long and sustained training to undergraduate students at UPR-C, thereby increasing their chances of acquiring the necessary skills to enter graduate school and continue research careers.

Building a campus-wide resource

Finally, a strategy that the IIR implemented to develop a culture of research at this undergraduate minority-serving institution was making sure the university community saw the IIR as a campus-wide resource. This was not easy to accomplish since most activities and personnel at the IIR were supported by external funds that respond to specific programmatic and disciplinary interests, with the NIH being a key funding source. As Carpi and Lents (2013) argue, since underfinanced, public and minority-serving institutions have fewer resources for planning and post-award administrative capacity, external funding is crucial for sustaining a minority-serving institution's undergraduate research efforts. The UPR-C is no exception. Yet, since externally funded projects often require extra resources to run effectively, they also have the tendency to function as isolated units with their own administrative structures and mechanisms (Golenko, Pager, & Holden, 2012). This can prevent their integration into the institutional fabric. In a tightly-knit institution, it can also deter participation from a number of faculty members who do not feel directly benefitted by the externally funded program, alienating potential mentors from engaging in research (Pickens, 2010).

With NIH support, the IIR lessened this effect by offering training on topics such as grantsmanship, workshops on research methodologies, IRB and post-award management, that were open to all interested faculty, students and administrative staff, benefiting a wide array of stakeholders across the institution. Other externally sponsored activities such as seminars, workshops, and symposia were also widely advertised for the benefit of the whole UPR-C academic community to promote research, support an academic and research culture and infrastructure among researchers, and facilitate interdisciplinary dialogs. IIR affiliates and research staff also spearheaded the development of institutional policies and procedures that promoted research beyond the IIR

such as: developing mechanisms to provide an allowance to research assistants (RAs) during field-research; creating protocols for compensating research participants; developing procedures to sponsor international speakers; establishing procedures for expedited acquisition of research equipment; hiring graduate-students from other UPR units as research assistants and other institutional innovations.

Most importantly, the UPR-C agree to re-invest 50% of the facilities and administrative costs recovered from IIR's research grants allocated to an IIR revolving account, allowing the IIR director to carry-over funds across fiscal years and assign them to where they are most needed. In turn, the IIR made strategic use of those funds investing them as seed money to support promising projects. This institutional commitment enabled the IIR to fulfill its broader mission "to foster applied, interdisciplinary projects that are relevant to the UPR-C service region" while contributing to strengthening the institutional research culture. For example, it enabled the IIR to provide additional support and seed-money grants to faculty and students from other disciplines, expanding the scope of impact to other applied projects of pertinence to the service area and to the NIH biomedical research agenda. Carpi and Lents (2013) argue that such institutional outcomes at minority-serving institutions are often undocumented. They state that while externally funded undergraduate research programs have been lauded as a transformative experience for students, the institutional effects of such programs at minority-serving, under-resourced institutions is often underappreciated and less well known. Similarly, the institutional impact of NIH externally funded programs at UPR-C went beyond the specific expected outcomes of the NIH biomedical agenda to encompass other unanticipated institutional transformations, such as developing new administrative procedures, changing hiring practices for all UPR-C faculty and creating interdisciplinary courses for students and faculty of all areas thereby diversifying the pool of mentors and the pool of students who could participate as research assistants.

Enlisting the collaboration of other externally funded programs in biomedical research training such as the NIH-NIGMS Research Initiative for Scientific Enhancement (RISE), the Howard Hughes Medical Institute, the Science Education Alliance, and the Genomics Education Partnership to enhance the students understanding of the scientific method, experimental design, and presentation of results was another important strategy for strengthening the IIR research infrastructure as these programs also provide supplemental support to faculty who are able to mentor additional students, some of whom participated in IIR projects and initiatives as well. An example of this type of collaboration is the *UPR-Cayey Week of Interdisciplinary Studies and Undergraduate Research*. With the leadership of the IIR and support from the Academic Dean in 2013, the activity showcased the work of more than 240 undergraduate students from RISE, Howard Hughes, the UPR-C Honor's Program, UPR-C General Education Program Capstone course, and the IIR. Students presented their work in oral or poster format. The event was widely advertised and sent a strong message regarding UPR-C's transformation from an exclusively teaching college to a university that also values research and research mentorship. Following this event, the Academic Dean designated a full day in May of 2015 when no classes were held to host an undergraduate symposium where more than 245 students presented their research, creative and community service projects.

Other innovations such as having double codification for courses sponsored by the IIR and academic departments or the Honors Program fostered the IIR's integration into the institutional fabric, encouraging more faculty and students to join its research program. The hiring of two tenure-track joint faculty appointments (with 50% time assigned to the IIR and 50% to an academic department) also encouraged greater integration among academic departments, their students, and the IIR. By gradually implementing these strategies, the IIR avoided operating as an island dedicated to the exclusive mission of securing externally funded programs, developing instead into a campus-wide resource for faculty mentors and their students.

Faculty and undergraduates research outcomes

By attracting and engaging local faculty as stakeholders, supporting their research and mentoring role across disciplinary lines, increasing the pool of mentors, and using external funds strategically to support the development of the IIR as a campus-wide resource, the IIR strengthened its capacity for promoting undergraduate research at a minority-serving institution in the face of economic and administrative challenges. The following outcomes evidence this achievement.

Increased faculty engagement and productivity in research

During a 10-year period, the number of faculty conducting research at the IIR consistently increased yearly, going from 7 in 2003 to 20 in 2013 (see Figure 2). Overall, in a 10-year period,

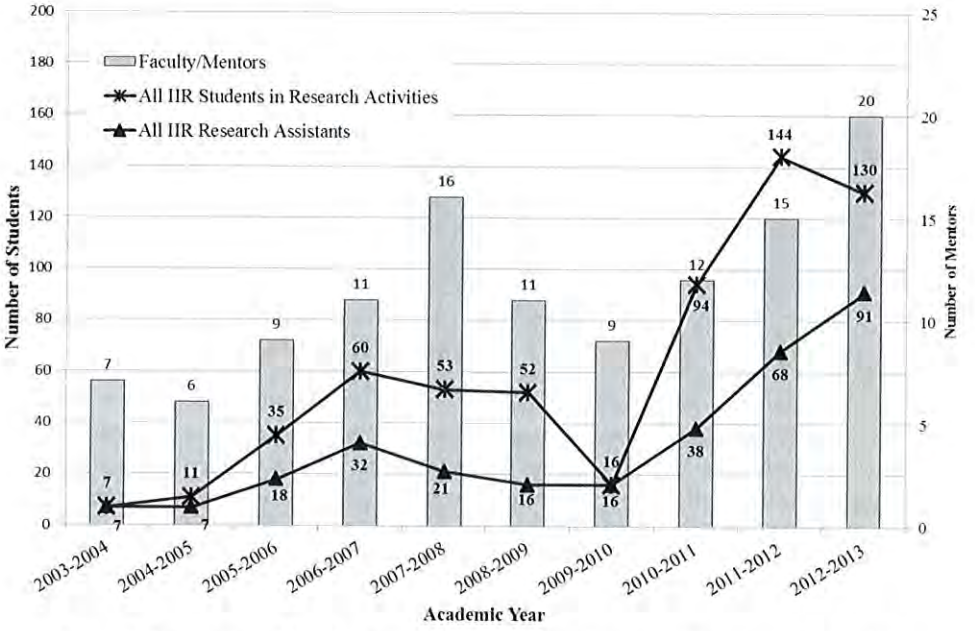

Figure 2. Students and Faculty/Mentors participation in research activities at the IIR (2003-2013)

the IIR supported a total of 54 faculty who published 81 peer-reviewed articles, submitted 57 grants, and made approximately 238 presentations at conferences. More importantly, they mentored more than 481 undergraduate students. Although UPR-C experienced a drastic loss of faculty, the aforementioned strategies, particularly the research-focused recruitment strategies, increased the number of faculty who could mentor students and, thus, the overall number of students who could engage in research activities.

In an institution that 10 years ago only considered teaching excellence as the primary criteria for tenure promotion, the research faculty has brought a great deal of prestige to UPR-C. One junior faculty, Dr. Javier Arce received the Presidential Early Career Award for outstanding investigators in 2013 (NSF, 2013). He holds a joint appointment between the IIR and the Biology Department (with 50% dedicated to each unit) and was the only researcher based in Puerto Rico who received this prestigious award. He has mentored 30 undergraduate students, many of whom have presented their research at international conferences and participated in national summer internship programs. Similarly, Dr. Patricia Noboa, another recent hire, won an international award from the United Nations' organization UNAIDS for her work with HIV (Noboa-Ortega, Ortega-Guzmán, & Feldman, 2014); she has mentored more than 25 students.

Increased research assistants in multidisciplinary areas

The above named strategies laid the groundwork for enabling *one of the single, most important conditions that needed to take place for the development of an undergraduate research culture at UPR-C: providing undergraduate students with the opportunity to work under the supervision of local mentors at their home institution.* Students could enroll in the aforementioned INTD 4116 course or any equivalent course in the Biology, Mathematics or Chemistry departments to work for one semester or more under the mentorship of the faculty member supported by the IIR. The IIR required that students write a research report and present at the UPR-C local student symposia (student travel off-Island was supported when funding was available). Undergraduates could also work on a voluntary basis or receive a stipend if the faculty had external or institutional funds to hire him or her. When needed, the IIR helped faculty recruit students into their projects by publishing the research title (along with the necessary RA requirements) so students can contact the faculty researcher directly. The IIR also developed other venues to provide students with research experiences, such as research-intensive semester and summer courses offered by local and invited faculty. Accordingly, the number of undergraduate students participating as RAs or enrolled in research-focused courses sponsored by the IIR increased from 7 in 2003 to 130 in 2013 (see Figure 2).

Students working as RAs emphasized, among other aspects, the important role that their mentors and those who belong to their mentoring communities at the IIR, played in their academic development (including the support of student peers). In a survey (administered from 2011 to 2014), students affiliated to the IIR and its NIH sponsored program BRIC wrote that the most valuable aspect of the experience was:

> *"Teamwork with peers with equal interests; obtaining and nurturing with knowledge and techniques that were unknown; receiving full support and professional assistance from the mentor and BRIC staff."*

> *"The strong ties with mentors and the friendships that provided support; in addition, the tools that will help me continue graduate studies."*
>
> *"The most valuable part of the experience was the communication between mentors UPR Cayey and members of BRIC program. They definitely guide students towards success. After doing research during the semester, we have the opportunity to present our research orally at the symposium of the Institute for Interdisciplinary Research, which reinforces our oral techniques."*

Students working on interdisciplinary teams also mentioned "having access to different research disciplines and having the advice of a professional in the area who guided us through each step" as a most valuable experience. The interdisciplinary research program sponsored by the IIR and the INTD 4116 course facilitated this increased involvement of faculty and undergraduate students from a wide variety of disciplines. As Figure 3 shows, from 2003 to 2010, approximately two thirds of the undergraduate students participating as RAs were from the natural sciences departments (Chemistry, Biology and General Sciences). There were few opportunities for students from other disciplines to engage in research. After the INTD 4116 course was created (between 2011 and 2013), the involvement of students from other areas in research projects sponsored by the IIR (especially from the social sciences, Education and Business Administration) gradually increased exponentially, to the point where their participation was almost equal to that of students from the natural sciences. This transformation made the IIR's student profile more representative of the UPR-C classification by the Carnegie Foundation as a Baccalaureate College of Diverse Fields with a Balanced Arts and Sciences/Professions Undergraduate Instructional Program.

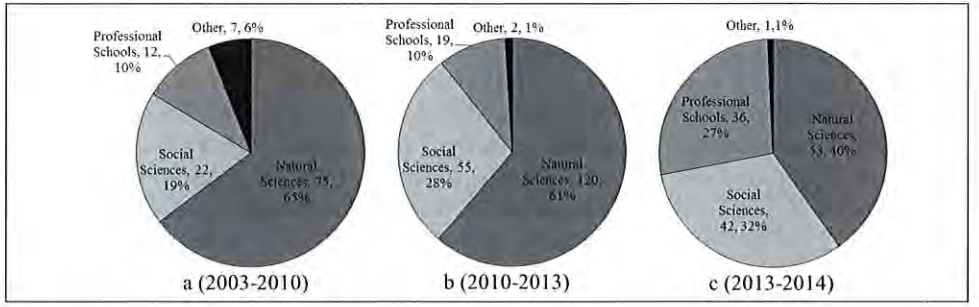

Figure 3. Areas of study of research assistants at the IIR: a) 2003-2004 to 2009-2010 (n=116), b) 2010-2011 to 2012-13 (n=196) and c) 2013-2014 (n= 132)

Increased graduation and admissions to graduate school

A key outcome of providing students with the opportunity of working under the research mentorship of local faculty is their enhanced engagement with their studies, leading to their successful completion of their BA. A significant difference is observed when we compare the six-year graduation rate of those students who had research experiences at the IIR with the graduation rate of the total number of students who enrolled at UPR-C. While the average UPR-

C graduation rate for the period of 2002-2007 was 43.2% ± 2.5%, IIR students had an average graduation rate of 61.2% ± 9.9% for the same period (t(5) = -5.167, p=0.004). The experience of participating in research also enhances a student's preparedness for applying and entering graduate programs. As Table 1 shows, 84% of the students who graduated after acquiring research experience at the IIR were accepted into graduate programs in Puerto Rico or in the states. In fact, students who participated in the IIR programs were 3.7 times more likely than students from the regular enrollment to apply and be accepted into graduate school. Without adjusting for academic or socioeconomic variables, students who acquired research experience at the IIR represent more than 56% (76/135) of students admitted into biomedical or health science graduate programs, even though they only represent 11% (156/1,381 students) of the overall graduate population between 2007 and 2013 (see Table 1; application and admission institutional data is not available prior to 2007).

Table 1. Comparison of Number of Applications and Admissions to Graduate Schools and Biomedical Graduate Programs of UPR-C/IIR and UPR-C Students.

Graduate School Status	IIR Students 2007-2013 (n=156)	UPR-C Students 2007-2013 (n=1,381)
Number (%) of all graduates applying to graduate school	129 (83%) (n=129/156)	445 (32%) (n=445/1,381)
Number (%) of all graduates admitted to graduate school	108 (84%) (n=108/129)	257 (58%) (n=257/445)
Number (%) of all graduates admitted to biomedical graduate programs	76 (70%) (n=76/108)	135 (53%) (n=135/257)

Providing undergraduate students the opportunity to work as RAs under the supervision of a mentor at their home institution played a crucial role in the IIR's success in increasing undergraduate participation in research and their success in being admitted to graduate school, more so than participating in research-oriented interdisciplinary courses. For example, when we compare the experiences of those students who only gained research experiences through course work, as opposed to those students who participated as RAs with local faculty, we notice that the second experience yields more positive results in terms of the students' acceptance to graduate programs. Overall, students who were RAs were 15% more likely to apply and be accepted to graduate schools than those who only took research-focused courses (see Table 2). As one RA stated: *"For me, this experience as a research assistant has been one of the most if not the most enriching experiences I've had in college. I think this experience has impacted both my educational as well as my personal life."*

Table 2. Comparison of Graduate Schools Status of IIR Research Assistants and IIR Students Enrolled in Research-courses only.

Graduate School Status	IIR Students Research Assistants 2004-2013 (n=106)	IIR Students Course Work 2004-2013 (n=40)
Number (%) of all graduates applying to graduate school	93 (88%) (n=93/106)	29 (73%) (n=29/40)
Number (%) of all graduates admitted to graduate school	81 (87%) (n=81/93)	21 (72%) (n=21/29)
Number (%) of all graduates admitted to biomedical graduate programs	59 (73%) (n=59/81)	12 (57%) (n=12/21)

Forming empowered, confident and committed students

To assess the experience of students who worked at research assistants under the mentorship of UPR-C faculty, questionnaires were self-administered at the end of each semester during the student symposium. This instrument included two sections with quantitative items and one section with qualitative items divided as follows: Part I, collected general demographic information; Part II, inquired about RA's research experience and their attitudes towards research in areas such as: interest in health-related research, familiarity with research methods and techniques, development of research skills, ethical aspects of research, presentation of written or oral reports with research findings, and interest in continuing graduate studies; and Part III, collected students' qualitative assessment by asking about the most valuable part of their research experience. In summary, results from this open-ended question display a diverse set of personal, academic, and social rewards, particularly in areas of personal development, including self-confidence, leadership, discipline, emotional growth and facing life challenges. One student, for example, stated: *"Aside from the opportunity to present your research in different scenarios, (this experience) transforms you into a person who is a fighter, with goals to achieve."* Another said: *"[the experience] helps you trust your abilities."*

Active participation in research also played a key role in maintaining students' motivation throughout college and the feeling that they belonged at the University. For instance, a student said: *"The most valuable part is when you begin to do research, you are in a lab, start reading data in English, begin to engage into a new unknown world and this new world becomes part of you... you begin to love what you do..."* Other students stated: *"This experience opened my knowledge and desire for research and helped me define my graduate studies goals,"* and: *"The experience of belonging to the Research Institute has given me the motivation to get adapted to the University because I feel that I am part of it."*

Commitment to social change and creative leadership were also pointed out as rewards of the RA experience. Some students commented that the most valuable part was *"Being part of the development of a research project that arises from my concerns as a human being, and seeing how it can be a model in order to create change in society," "To help improve the social situation of PR by providing new knowledge on violence in young Puerto Ricans,"* and that *"The best part was joining the program and interacting with the community to know about their concerns."* Finally, one student mentioned that *"[I had] the satisfaction of being part of a project that leaves footprints in society."*

Most frequently, students described how the experience as research assistants enhanced their professional skills and academic coursework by giving them the opportunity to integrate and apply what they had learned. In their words:

> *"This (research experience) creates in us a different view on how to apply all the knowledge acquired through undergraduate studies,"*
>
> *"It is a rewarding and great learning experience. It contributes to our academic performance and expands our vision about society,"*
>
> *"I would recommend this [RA] experience, because it enriches you as a student and increases the analytical and critical abilities of the person. I was able to apply everything I have learned in the courses I have taken,"*
>
> *"I developed research and technical skills,"*
>
> *"I got to learn dynamics and skills that are not offered in the courses I have taken so far,"*
>
> *"I could recommend this experience because it changes your life in a positive way... it develops a real life application and encourages teamwork," and*
>
> *"This was my best experience in my four years of undergraduate studies."*

Conclusions

Scholars agree that engaging undergraduate students in research is a highly effective strategy for retaining them and sustaining them in a research career path (Brown, Daly, & Leong, 2009; Boyer Commission, 1998; Cox & Andriot, 2009; González, 2006; Lopatto, 2003; MacLachlan, 2012). The Boyer Commission clearly established that mentored research experiences can inspire undergraduate students to be more adaptive, resourceful and better able to meet the challenges of specialized training and professional life (1998, p. 18). The effects of these experiences are particularly strong with Latinos and other students from underrepresented groups (Lopatto, 2007; Russell, Hancock, & McCullough, 2007). However, Latinos are particularly underrepresented among students attaining college degrees in general (Vernez & Mizell, 2002). Hispanic serving institutions (HSIs), on average, receive only 69 cents for every federal dollar of funding that all other higher education institutions receive (Hispanic Association of Colleges and Universities, 2015). Institutional approaches, thus, need to be rethought to mitigate long-term inequalities in order to uncover and engage the best talent for research.

UPR-C has pioneered important transformations leading to this goal, developing a successful model for training students from underrepresented low-income backgrounds at a HSI through its IIR. This article examined the strategies and approaches leading to this successful outcome facilitated by the IIR at this 99% Hispanic serving institution. It described the IIR success of supporting undergraduate research by supporting faculty over the span of ten years (2003-2013) and identified the most significant strategies leading to it. Of foremost importance was the strategic planning effort "from below" that addressed the need to create a supportive institutional environment for faculty to develop their research and mentor students. With this vision in mind, the IIR at UPR-C engaged faculty as stakeholders, supported their research initiatives, increased the number of local research mentors, and operated as a campus-wide resource. By providing pre- and post-award administrative support, interdisciplinary seminars and symposia, training workshops for faculty and students and continuing hosting the Census Information Center, the IIR provided a culturally responsive context for mentoring in which the research endeavors of local faculty and students could flourish and have continuity. This strategic vision encompassed, in fact promoted, supporting faculty research at this undergraduate institution through system-wide transformations launched by stakeholders and collaborators that gradually made significant transformations in the institutional culture and administrative environment.

Currently, UPR-C has an exceptional record in training underrepresented students for research careers. With only 3,800 students in 2013, UPR-C ranks 18th in the US as source institutions for Hispanic PhDs in natural and social sciences (2008-2012; NSF, 2015). The results of the strategic vision and approaches described in this article are tangible and have significantly impacted interdisciplinary undergraduate research at this undergraduate under sourced minority institution, transforming student lives with research opportunities not available before. In the words of a student: *"I think the experience of being a Research Assistant changed my life... through this, I found my road to the future and my goal is to attend graduate school, [and obtain] a PhD."*

Authors' Note

The authors would like to acknowledge the contributions of Prof. Fernando Vazquezcalle, Director of UPR-C Assessment and Planning Office for providing the institutional data presented. This work was conducted with support (in part) from the National Institute on Minority Health and Health Disparities / Building Research Infrastructure Capacity (BRIC) Program Grant # P20MD006144 to UPR-Cayey. The views expressed do not necessarily reflect the official policies of the Department of Health and Human Services. The corresponding author is Isar Godreau.

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