Championing Hispanic Student Success following Natural Disasters in Puerto Rico

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As a School Psychologist professor working in the Teacher Preparation Program (TPP) since the year 2000, Dr. Bellido has taught the following courses: Human Development, Educational Psychology, Learning Evaluation; Theory and Methodology in the Teaching of History and Social Sciences; and Student Teaching of Mathematics and of Social Studies in Secondary School among others. As a collaborator in the Psychology Department, she teaches Introduction courses to School Psychology, Fundamentals of Psychology, and the grad course of Learning and Cognition. As the Institutional Coordinator for the University of Puerto Rico at Mayagüez (UPRM) accreditation under the Council for the Accreditation of Educator Preparation (CAEP), she directs, coordinates, and work in various committees that must complete evaluation cycles to assess the quality of the unit, the programs, teacher candidates, and alumni impact of the TPP. These evaluation cycles require a diverse toolkit of instruments, educational materials, and protocols to collect and analyze usable and useful data for monitoring and improving the TPP. Efficient and effective collection, analysis, and presentation of results to stakeholders are important parts of the work done for the TPP evaluation cycles. As the UPRM Center for Professional Enrichment coordinator for 12 years, Dr. Bellido was in charge of organizing faculty professional development activities. This placed her in an advantageous position to disseminate vanguard information about education, evaluation theory, and practice which can be useful for both teaching and research faculty. As the UPRM Resource Center for Education Research and Services Center (CRUISE) coordinator since 2002, she has directed and or evaluated more than twenty educational research, professional development, and outreach projects from 2002 to 2020. These educational research and service projects include higher-education ecosystems for retention and graduation of STEM scholars, project-based learning instruction, classroom action research, professional and virtual learning communities, creating online educational materials, professional development and training for pre-service and in-service teachers, professional development for higher education faculty and a major Math and Science Partnership project. CRUISE has also worked with projects serving k-20 students directly. All these projects share common themes of the creation of curricular materials and applying the latest educational research to improve the teaching-learning dynamics giving Dr. Bellido extensive experience using evaluation to improve learning strategies from primary to graduate school.

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Professor Oscar Marcelo Suarez joined the University of Puerto Rico - Mayagüez in 2000. A Fellow of ASM International, he is the Coordinator of the Materials Science and Engineering graduate program, the first of its kind in Puerto Rico. He is also the director of the university's Nanotechnology Center Phase II, which is supported by the National Science Foundation. Currently, his work focuses on aluminum alloys, metal matrix composites, and concrete modified with nanoparticles as well as biocomposites for biocidal applications. Important components of his interests are education and outreach to underrepresented minorities.

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rapid prototyping of information processing systems, embedded cyber-physical systems, and engineering education. He is the lead author of the textbook Introduction to Embedded Systems: Using Microcontrollers and the MSP430 (Springer 2014). From 2013 to 2018 served as Associate Dean of engineering at UPRM. He currently directs the Engineering PEARLS program at UPRM, a College-wide NSF funded initiative, and coordinates the Rapid Systems Prototyping and the Electronic Testing and Characterization Laboratories at UPRM. He is a member of ASEE and IEEE.

Abstract

Natural disasters, such as 2017 hurricanes Irma and María, the 2020 earthquakes in Puerto Rico and the ongoing COVID-19 pandemic, affect students in many aspects including economic, socio-emotional, and academic performance progress. To ensure that students can cope with the aftermath of such searing events, it is necessary to develop initiatives that address these three aspects. Satisfying the financial need is essential, but a long-term solution is mandatory. Hence, providing socio-emotional and academic support and cultivating a sense of purpose are critical to prevent attrition.

To secure continued STEM success among students affected by natural disasters, the National Science Foundation has funded several projects at the University of Puerto Rico, a Hispanic Serving Institution. This manuscript presents four NSF-funded projects sharing the common goal of providing support to STEM students to ensure that they succeed despite the said challenges. The first project, titled *Nanotechnology Center for Biomedical, Environmental and Sustainability Application,* leans heavily on research teams dedicated to design new Nanotechnology platforms to address biomedical and environmental challenges and simultaneously trains a new generation of nanoengineers and nanoscientists throughout the educational echelon starting from public intermediate schools through doctoral programs. The second project, entitled *Ecosystem to Expand Capabilities and Opportunities for STEM-Scholars (EECOS),* developed an integrated framework that provides support to 62 low-income, talented, STEM students who were severely affected by Hurricane María and 2019-2020 earthquakes (58 undergraduate and 4 graduate). The project provided participants with financial, academic, socio-emotional, and career motivation support needed to complete their programs. The third project, *Program for Engineering Access, Retention, and LIATS Success (PEARLS)* addresses college access and economic hardships of Low-Income Academically Talented Students (LIATS). It aims at increasing the retention and academic success of talented engineering students coming from economically disadvantaged families. The fourth project, *Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP),* has developed an interdisciplinary curriculum to educate cadres of Hispanic students on infrastructure resilience to temper and to overcome the effects of such natural disasters. Three campuses of this institution system collaborate in this interdisciplinary undertaking. Participating students are pursuing undergraduate degrees in engineering, architecture, and surveying who take the entailed courses together and participate in co-curricular activities (both online and in-person through site visits). The new curricular endeavor prepares them to design infrastructure that can withstand the impact of natural events. The expect outcome is to form cohorts of graduates ready to take on real-life infrastructure failures caused by disasters and provide them with an edge in their future professions.

The present work provides a range of scalable and portable strategies that universities with underrepresented minorities in STEM programs could deploy to address the immediate and continued needs of students affected by natural disasters to secure academic success. These strategies can contribute to the development of professionals with the skills and experience to deal with severe circumstances such as those effected by natural disasters as well as the preparation to solve infrastructure challenges.

Introduction

Natural disasters, such as hurricanes, earthquakes, tsunamis, droughts, fires and pandemics, affect students in many aspects including economic, socio-emotional, and academic performance

progress, among others. To ensure that students can cope with the aftermath of such searing events, it is necessary to develop initiatives that address these three aspects. In the short-term, satisfying the financial need is essential, but a long-term solution is mandatory. Hence, providing socio-emotional and academic support and cultivating a sense of purpose are critical to prevent attrition.

Hurricane María made landfall on September 20, 2017, near Yabucoa, Puerto Rico causing major damage to the island's infrastructure. In the aftermath of the storm, Puerto Ricans had limited access to clean water, electrical power, communications, and basic healthcare services. The devastation led to over 3,000 deaths, and a very slow process of recovering due to the financial crisis of the Island [1]. The 2020 seismic "swarm" that struck the southwest of Puerto Rico included over 123 earthquakes of magnitude 3 or higher, with the most destructive quake in a century, a magnitude 6.4. that jolted residents awake in the predawn hours of January 7 [2]. Such seismic activity caused severe structural damage, including the collapse of a public school and over one hundred houses, and rendered hundreds of public and private buildings inhabitable. Hurricane María and the 2020 earthquakes increased awareness regarding the disproportionally large impact of natural disasters on vulnerable populations, including university students. This increased awareness motivated faculty to come together to propose projects to address the challenges experienced by students in the aftermath of natural disasters.

According to the National Science Foundation (NSF), "NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These broader impacts may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project." [3]. This manuscript describes the broader impact and contribution of four projects to the achievement of the societal goal of increasing resiliency among populations that are impacted by natural disasters.

NSF-Funded Projects

This section describes the four projects that were funded by NSF at the University of Puerto Rico that champion Hispanic student success following natural disasters.

Nanotechnology Center

As one of the NSF Centers for Research Excellence in Science and Technology (CREST), the Nanotechnology Center for Biomedical, Environmental and Sustainability Applications Phase II (National Science Foundation Award Nº HRD-1345156) was organized in four groups: three addressing research endeavors and one focusing on educational activities [4] The Center produced a robust and comprehensive research underpinning on novel cancer therapy materials, new composites for environmental remediation, and sustainable nanostructured materials applications. The range of peer-reviewed publications included several articles that received awards. In terms of educational impact, the Center fostered the establishment of the first Materials Science & Engineering (MSE) graduate program in Puerto Rico and helped support other new Engineering doctoral programs at our university. The outreach component impacted more than two thousand students from public middle and high schools, as members of the MSE clubs set up and supported by the Center [5], [6]. A videogame with *Nanito*, the Center's mascot,

helped children to become familiar with advanced Nanotechnology concepts. The Center's research activities involved nearly one hundred graduate and undergraduate students who partook intensively investigating advanced Nanotechnology domains. It also contributed to the formation of three Engineering doctoral programs at our university. Furthermore, more than two thousand students from public middle and high schools have participated in the Center's outreach activities.

After the 2017 hurricanes, the strategic network and alliance with public schools established through the MSE clubs provided an underpinning for the involvement of the Center's staff, professors, and students to partake in the recovery efforts. Utilizing the *Nanomobile*, the official transport used for outreach activities, the team joined the US National Guard to distribute meals ready-to-eat and bottled water among the most affected neighborhoods in the university town. Of particular interest to the Center were those families whose children were members of the MSE clubs. Assisted by school counselors, the Center's personnel tended to those households. The resilience of these students and their teachers is demonstrated in figure 1. This figure is the first annual meeting of the MSE clubs held only eight months after the storm when more than 600 club members attended this special event.

After the swarm of strong seismic activities in January 2020, the Center's teamed up to assist those families evacuated from houses damaged by the earthquakes. In these interventions, the Center's students became aware of the importance of the alliance between a university and the served community [7]. The Center developed a "town-gown" partnership through its summer camps for public school teachers and high schoolers. As both cohorts partook in research activities in affiliated campus labs, families were invited to join the opening and closing ceremonies of the four-week camp. These strategies for the successful development, evaluation, and sustainability of community–university partnerships have proven very successful. In this case, the partnership along with the MSE clubs permitted counseling graduating high school student about careers with steep return investments, as Engineering majors [8].

Figure 1: 2018 annual meeting of the MSE clubs demonstrating the use of nanoparticle platforms and macrophages in oncological treatment.

EECOS

Following Hurricane María, the Ecosystem to Expand Capabilities and Opportunities for STEM-Scholars (EECOS) was designed to provide students that suffered the loses shown in figure 2 with (1) financial support, (2) academic support, and (3) socio-emotional support to increase retention and graduation, (figure 3). In addition, two supplements on the original proposal were added to extent the support to STEM-Scholars that were severely affected by the earthquakes of 2020.

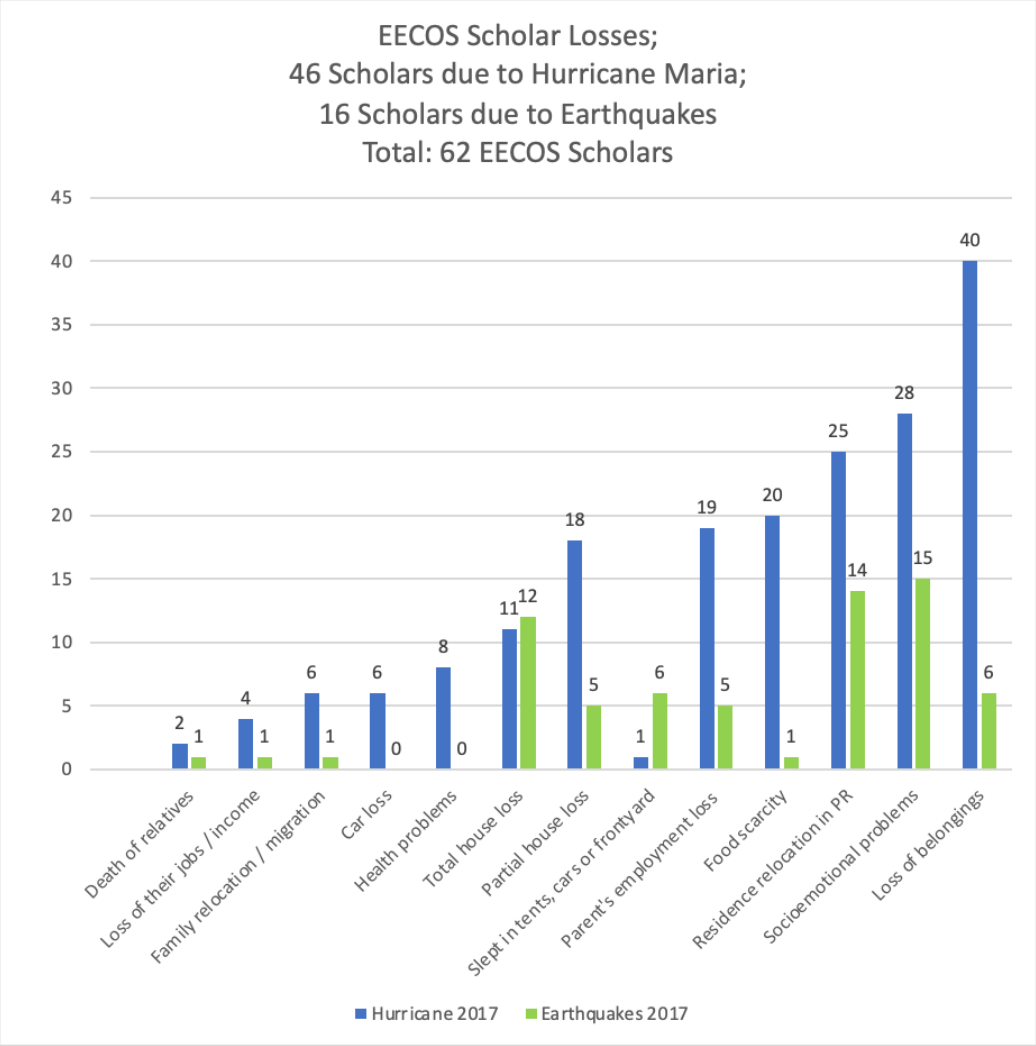

Figure 2. EECOS Participant Losses due to Natural Disasters

The EECOs project has created a baseline characterization with the necessary elements to be used by institutions to support students after a catastrophic natural events and has been able to help in their recovery and resilience processes with a 98% rate in STEM major retention, 65% of the EECO scholars needed referrals to psychological counseling services, and 54% got involve in research. This project emphasizes the importance of developing and implementing an ecosystem of support that includes academic and socioemotional support systems, and the validity of the adage that financial aid alone cannot increase student success. Most outcomes for established goals have been reached, meeting or surpassing accomplishment levels indicated in the evaluation plan. For Goal 1, data shows that financial support has been provided consistently to

support the Scholars to complete their degrees. In fact, during the first two years of the Project, twenty-one (21) Scholars finished their degrees and continued graduate studies or secured a job in STEM fields. For Goal 2 and Goal 3, the data show that they have not only received an academic and socio-emotional support that augmented their sense of belonging, but a synergistic effect that has increased the possibilities to continue in their programs, as well as has opened the doors in research and COOP practices.

Figure 3: EECOS Support Ecosystem

PEARLS

The Program for Engineering Access, Retention, and LIATS Success (PEARLS) addresses college access and economic hardships of Low-Income Academically Talented Students (LIATS). The project provides financial and academic support to participants. Concurrently, the undertaking investigates the effectiveness of an institutional intervention model seeking to increase the retention and academic success of talented engineering students coming from economically disadvantaged families. PEARLS includes a comprehensive intervention model that integrates elements from Lent's et al. Social Cognitive Career Theory and Tinto's Departure Model [9],[10]. Financial support is provided through a scholarship program aimed at mitigating economic hardship faced by LIATS. There are 92 students enrolled in the program distributed among ten different engineering programs. Results to date indicate that 97.9% of program students perform above the college-wide average. Freshmen retention is 97.1%, while 100% of sophomores, juniors, and grads persisted by re-enrolling for their next study year. When compared to similar indicators among the general engineering student population, these statistics reveal significant improvements [11]. Figure 4 presents part of the first cohort of PEARLS scholars along with their faculty mentors.

Figure 4: First cohort of PEARLS scholarship recipients and the faculty team involved.

RISE-UP

The Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP) was designed in the aftermath of Hurricane María in response to the need of training future professionals to design and build infrastructure that can withstand the impact of natural events. After the natural disaster, it became evident that multiple disciplines needed to come together to rebuild the damaged infrastructure using new paradigms. The project is a collaboration among three campuses. It includes a novel interdisciplinary curricular sequence that emphasizes the development of research skills and conducting case studies to turn them into hands-on solutions for real problems/projects [12], [13].

RISE-UP consists of four courses that are part of a minor degree complemented by internship and undergraduate research opportunities. Courses are taken sequentially in a process that starts with the presentation of basic content and techniques, to the application of that knowledge in an integrated design project. To date, a total of 64 students have enrolled in the program, where 100% of students have conducted case studies related to infrastructure damages caused by natural disasters. Figure 5 presents part of the first cohort of RISE-UP students and faculty.

An example of integrating real life problems in the curriculum was the student involvement after the January 2020 earthquakes. During the first course of the curricular sequence, students learned methods to assess building structural vulnerability and damages. These lectures were followed by a site visit where they conducted case studies to assess the seismic vulnerability of several buildings. Following the 2020 earthquakes, RISE-UP students assisted faculty and professional engineers in assessing structural damages at our campus following the earthquake. Students indicated that witnessing firsthand the complexities of assessing infrastructure damage during and after an intense seismic event enhanced their awareness of the significance of the engineering and architecture professions [14]. Through experiential learning RISE-UP students have demonstrated a greater awareness of their role as contributors to solving the real infrastructure challenges caused by natural disasters which has led to an increased enthusiasm and interest in their future professions.

Figure 5: First cohort of RISE-UP students and the faculty team involved.

Broader Impact Synergy

The four projects presented hereby have contributed broadly to achieving the societal goal of increasing resiliency among vulnerable populations impacted by natural disasters. Of the four projects included in this paper, the Nanotechnology Center was the only project active when Hurricane María struck Puerto Rico in 2017. This circumstance and the community engagement environment created by the Center, allowed staff and students to promptly join existing relief efforts and to design and carry out high-impact operations assisting households with children members of the MSE clubs. EECOS, PEARLS and RISE-UP were conceived in the aftermath of the natural disaster and began on October 1st, 2018. The projects share the common goal of increasing resiliency among STEM students to succeed in their studies and careers. They have helped participants to develop resilience because aspects that affect them not only as students, but also as complete human beings have been addressed. These are the types of projects that make participants feel that they belong to a community that cares about their problems and supports them in reaching their goals. Table 1 shows the individual project broader impact. The authors participated in a panel session at the Hispanic Association of Colleges and Universities (HACU) 13th International Conference. The conference theme was "University Resilience and Renaissance: The Challenge of Climate Change and Other Global Shifts." During the panel session, questions from the audience and discussion among panelists contributed to making evident that having four projects funded concurrently with shared overarching broader impacts has increased visibility and impact and has positively increased retention of STEM students at our university [15].

Table 1: Broader Impact by Project

Project	**Broader Impact**
Nanotechnology Center	- Broad research activities involved nearly a hundred graduate and undergraduate students who investigate advanced Nanotechnology platforms for biomedical and environmental applications.

	- The comprehensive knowledge created helped develop novel cancer therapy materials (based on hyperthermia and luminotherapy), new nanomaterials for environmental remediation and low-carbon footprint technologies. - The Center helped established the first Materials Science & Engineering graduate program in Puerto Rico and created sixteen Materials Science and Engineering clubs in public middle and high schools serving mostly low-income households.
EECOS	-The project has provided an ecosystem to increase retention and persistence of STEM scholars severely impacted by Hurricane María and scholars who were displaced from their homes by the earthquakes that the island suffered at the beginning of 2020. The three components of this ecosystem are: 1) Financial Support, 2) Academic Support, and 3) Socio-Emotional Support. This is the first time a project uses financial, academic, and socio-emotional support to assist a STEM scholar severely distressed by a disaster. This research is producing a baseline characterization of the tools that need be used to provide faster and more effective responses to unexpected hardship situations in the future.
RISE-UP	- The initiative benefits society by increasing capacity of engineers, surveyors and environmental designers to work on issues related to resiliency and sustainability, and the development of a database of case studies available for research and modeling. - This project will have a great social impact for current recuperation efforts and minimizing future impact of natural events.
PEARLS	- A hybrid model sets as its main research quest identifying the factors leading to the success low-income, academically talented students (LIATS) in engineering with the ultimate goal of providing guides for institutional policies aimed at reinforcing recruitment practices, improving graduation rates, and reducing time to graduation. It provides a coherent & portable program of curricular and co-curricular activities based on high quality evidence-based practices, providing undergraduate and graduate scholarships serving as frame to study the proposed success-leading model impact.

Conclusions

The present manuscript describes how four projects supported by the US National Science Foundation created an institutional platform to provide financial assistance, relief, mentoring, and formal education to students severely affected by multi-hazard scenarios prompted by

natural catastrophic events. A common goal has been to form cadres of college students fitted with the necessary resources that can secure their success with a resilient underpinning.

Such multifarious approaches converge so as to enhance the likelihood that the projects' participants are successful in the various aspects of their studies, careers, and lives. The projects have implemented both novel as well as well-known effective strategies and are documenting the effectiveness the strategies on talented STEM students. The support provided to the students increases their sense of belonging and increases resiliency. The synergy among the four projects amplifies the broader impact related to the societal goal of increasing resiliency and preparedness to face the challenges imposed by natural disasters.

The lessons learned indicate that in the aftermath of multi-hazardous events, faculty and administrators must not expect that at-risk students will seek the services needed to succeed. Institutions need to proactively identify and reach out to those at-risk students to offer and coordinate the academic, financial, and socioemotional services they need to succeed. As faculty, we need to be advocate and champion for talented students who have been impacted by catastrophic event if we want to retain and graduate them to become successful STEM professionals.

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The Nanotechnology Center team involved 20 faculty members and was led by Agnes Padovani-Blanco, Madeline Torres-Lugo, Arturo Hernández-Maldonado, Oscar Perales-Pérez (RIP), and Oscar Marcelo Suárez (project director).

The PEARLS team is comprised of the following faculty: Manuel Jiménez, Oscar Marcelo Suárez, Sonia M. Bartolomei Suárez, Aidsa Santiago Román, Luisa Guillemard, Carla López del Puerto, Nelson Cardona, Nayda G. Santiago Santiago, Pedro Quintero, Anidza Valentín, and Manuel Rodríguez

The RISE-UP team is comprised of the following faculty: Carla López del Puerto, Humberto Cavallin, Jonathan Muñoz, José Perdomo, Oscar Marcelo Suárez, Drianfel Vázquez, Fabio Andrade, Ismael Pagán, Luis Suárez, Luis Montejo, Aidcer Vidot, Luis Daza, Luisa Guillemard, and Walter Díaz.

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