ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38275

Voices of experience: Enhancing learning on resilient infrastructure and sustainability through servingness

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Hello, my name is Rubén E. Leoncio Cabán and I am 22 years old, I come from a town called Lares in Puerto Rico. It is rural and small, and its charm is part of what makes me like it so much. I'm currently an undergraduate student pursuing a double bachelor's in electrical engineering (in power electronics) and in computer engineering (in software). Additionally, I have completed a minor concentration entitled: Integrated practice of engineering and architecture, part of the program of the Resilient Infrastructure and Sustainability Education Undergraduate Program (RISE UP). As you can see, I am a student with a great passion for knowledge and learning new things. During my life, I have had the opportunity to learn and enjoy learning, not only in the academy, but also in the day-to-day activities that arise. From planting and caring for animals to taking classes and doing research, everything that allows me to learn and develop new skills pleases me.

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In Puerto Rico, the exposure to extreme environmental conditions has become part of a new normal. Because of this, the education of professionals to face this new reality is part of the demands of the academia of the present, and to the core of it the concept of servingness as a tool contribute to the formation of students' and faculty sensibility to social dynamics connected to the educational experiences. The Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP), funded by the Hispanic Serving Institution (HSI) program of The National Science Foundation (NSF), has been conceptualized including elements of servingness by addressing aspects connected to the learning experience, leadership identity, critical consciousness, academic and research aspirations, and civic engagement all in the context of Puerto Rico's current infrastructural needs. This paper addresses those dynamics by means of the voice of RISE-UP participants, accounting for how the experience generated by the crossroads that the program creates between the professional interdisciplinarity, the approach to infrastructure's sustainability, and the concept of resiliency, have impacted the experience of servingness for students in the program.

Keywords: servingness, non-academic outcomes, experiential learning

1. Introduction.

In a world that continuously changes, education must adapt to the challenges posed by those changes. One aspect that has been more and more into question in recent times is the effectiveness of an educational paradigm in which students are presented through Academia with well-defined and discipline-cut problems, in which has been associated with the tradition of the technical rationality [1]. Therefore, in most cases the academic preparation of scholars on infrastructure-related disciplines takes place in disjunct professional domains, rarely tackling interdisciplinary problem-solving, nor focused on a systematic understanding of research results and lessons learned from previous disaster experiences.

The Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP) is a collaborative project funded by the Hispanic Serving Institution (HSI) program of The National Science Foundation (NSF). The program's goal is to develop an interdisciplinary curriculum among three campuses at The University of Puerto Rico. The new curricular endeavor prepares students to design infrastructure that can withstand the impact of natural events[2]. The curricular sequence consists of 15 credits as shown in Fig. 1.

The program's broader impact is to benefit society by increasing the 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, teaching and modeling. RISE-UP aims to serve participating students by focusing on both academic and non-academic indicators of servingness.

Level	RISE-UP Courses	Credits
4	INCI 5036: Design-Build Project Delivery	3
3	INCI 5010: Resilient and Sustainable Design and Construction	3
	Internship / Undergraduate Research	
2	INCI 5996: RISE-UP Seminar Series	3
1	ARQU 4147: Fundamentals of Integrated Practice for Resilient and Sustainable Infrastructure	3

Fig. 1: RISE-UP curricular sequence.

According to the National Science Foundation, "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]. The HSI program at NSF aims to broaden participation of Hispanic students and expand their pathways to pursue education and careers in science, technology, engineering, and mathematics (STEM). Higher education institutions must aim to serve the students that they are enrolling. Servingness is the degree to which HSIs both champion and facilitate Hispanic student success [4]. Garcia, Núñez, and Sansone [5] indicate that servingness can be measured through academic and non-academic outcomes. Examples of academic outcomes include retention and graduation rates. Examples of non-academic outcomes include the development of academic self-concept, leadership identity, racial identity, critical consciousness, graduate school aspirations, and civic engagement [6].

RISE-UP participants, through the voice and accounting of how the experience generated by the crossroads that the program creates, share how they are served by the program. The experiences generated between the professional interdisciplinarity, the approach to infrastructure's sustainability, and the concept of resiliency have impacted the experience of servingness for students in the program. This paper presents students' reflections on the contribution of RISE-UP in students' development of the following non-academic outcomes of servingness: leadership identity, critical consciousness, research and graduate school aspirations and civic engagement.

2. Methods and Results.

The methodology selected for this study is based on case studies. Case studies can be used to gain insight on in-depth personal perspectives about attitudes, behaviors, meanings, and experiences by obtaining details from several relevant or involved sources related to a project [7], [8].

In a very particular way, the data for this paper is produced by testimonials and reflections from the authors, who are former students from RISE-UP. The sample includes four undergraduate

engineering students. The data consists of reflections on testimonies that were gathered from interviews in which the coauthors of this article expressed their views about the program. Those segments that represented lived experiences aiming to servingness were identified and after a year from being interviewed each student was asked to expand and reflect on their original narrated experience. Through both of these narratives, students expressed their insights about how the program served them and how their work in courses and research experiences prepared them to serve their communities.

Each of the following sections include the original testimony from a student, followed by the corresponding reflection and expansion of their narrative. Each represents the students' experience in their 'own voice'.

2.1. Developing leadership identity.

> We work in interdisciplinary groups where there are civil engineers, electrical engineers, architects, and surveyors. We are given the opportunity to design a low-cost residential community after a natural event. It is practically as if it were a design firm, and we were the designers of the company. Each group defines their schedules, in my case we meet once a week where we can gather our individual progress and then together, we know what our next step is going to be. It is very interesting to know how the other disciplines think, that is, people from different campuses and different programs, because not all of us see problems in the same way and that helps us to recognize that wow, the same problem can be approached in different ways depending on your discipline [9]

Starting the first day taking classes in the RISE-UP program, students form interdisciplinary groups, where they can exchange views and ideas about different topics, broadening their perspective. The students work on hands-on Project-Based Learning (PBL) projects, in which they face situations that require interdisciplinary teamwork to reach solutions. In the process, students develop different leadership dynamics, through which they either lead and/or cooperate with the other disciplines involved in RISE-UP. During the first course [INCI /ARQU 4147] new concepts and terms are introduced and discussed with the various fields and their different perspectives brings a richer learning experience that cannot normally be acquired in a typical course. Also, the students in interdisciplinary groups conduct case studies on the field. These case studies are a very fruitful experience that lets students use their knowledge in real cases. In the second course [INCI 5996] students are exposed to information modeling programs such as QGIS and Revit where they learn how to use designing software in interdisciplinary groups, in a similar way that is done in the industry. Then students practice the learned skills in real-world applications. The third course of the program [INCI 5010] presents real-world cases and discusses the different areas of expertise, to visualize how a harmonious design, between engineers, architects, and surveyors, can become a great design. In the final part of the program, [INCI 5036] students are taught the designing steps and processes and apply them in the designing of a structure. This leaves students with a great advantage over their university peers that are not exposed to these types of experiences.

2.2. Creating critical consciousness.

> I believe that the entire RISE-UP program, that is, all the experience, the topics that we touched on in the classes, the interdisciplinary experience was something very valuable. Now that I am in the workforce, I am seeing the fruits [of the program] directly because I feel well prepared to work with people who are not within the engineering field and in the approach to problem solving with the technical tools that I learned within the program. I feel that this is a super benefit because I can see the ways in which information technology can benefit us and can benefit our interaction within the team. I would say that this is the most tangible impact of the program [10]

After witnessing firsthand, the complexities of assessing infrastructure damage during and after the recent natural catastrophes in Puerto Rico, these experiences enhanced the awareness of the significance of the engineering and architecture professions for all students participating in the program. It also increases consciousness of the role they might play in ensuring the safety of the public both immediately after a natural disaster and in the face of future events.

During the Puerto Rico's earthquake swarm of 2020, students were able to participate in teams dedicated to assessing the structural damage to buildings on the University of Puerto Rico – Mayagüez (UPRM) Campus. The teams were comprised of members of the faculty and both graduate and undergraduate students. This opportunity allowed participants to put into practice knowledge gained in the RISE-UP fundamentals course, as well as specialized classes from the civil engineering curriculum. Students stated that the experience gained from the RISE-UP courses was particularly beneficial as it allowed them to actively participate and make meaningful contributions to damage assessment reports. Moreover, the frameworks that were presented in the RISE-UP program, in particular collaborative teamwork and interdisciplinarity facilitated through information technology, helped them develop a tool that was useful not only to civil engineers, but also for the rest of the academic and university community. This mindset led them to develop a GIS model which gathered all the information from the reports, and later develop infographics that were accessible to everyone in the community. RISE-UP allowed students to experience in a tangible manner the social impact of their profession and the responsibility they have as professionals in helping to ensure the safety of others.

2.3. Scaffolding academic and research goals.

> What I could get the most out of [RISE-UP] is to help me do research. I knew that I was attracted to the subject of research, and I knew that I was attracted to academia, but I did not have an experience that I could say I am confident that I have the skills and RISE-UP achieved that. After taking the summer research course, I was able to continue, [developing] a poster, we also had a [paper] publication. That was a

> super big advantage that I had, for example, to get internships and have more experience on writing technical literature. It has helped me a lot (...) After participating in RISE-UP, I had more confidence in my skills as a researcher thanks to the summer research course [INCI 4998, Internship/ Undergraduate Research]. The following year [2021] I was able to participate in a summer research program outside Puerto Rico and a lot of things from my resume came from RISE-UP courses and projects. The people I met, especially professors, were very helpful too because we created stronger connections working on our [RISE-UP] projects than a regular classroom setting. I was able to get very strong letters of recommendations from them for summer research as well as grad school applications. On that topic, the program also helped me gain confidence when deciding to pursue graduate studies and the application process. I found myself being more open to research topics outside of my comfort zone including interdisciplinary projects. I can say my original goal for the future of being a university professor has not changed, but now I am clearer of the steps I need to take to achieve that goal. I also have many more ideas about possible research topics that include resilience and sustainability, especially in the setting of Puerto Rico.[11]

As mentioned by a former RISE-UP student, participating in the INCI 4998 research course was a beneficial experience to branch out and work as a researcher both locally and with another institutions. Summer research experiences are one of the most important steps a student can take to determine if they wish to pursue graduate studies and can have a positive impact on student retention, confidence, and development of critical thinking skills [12]. In the context of Puerto Rico, many of the summer research experiences offered come from institutions in the mainland (continental US), which means in-person research for a Puerto Rican student requires housing and transportation as well as regular expenses such as food, or a stipend that will cover those costs. These programs tend to be competitive and difficult to access without prior research experience, or sometimes students without proper counseling may not be aware of their existence. Having a summer experience that can introduce students to research topics and methods can help them better determine if graduate school is a viable path to reach their career and personal goals.

Another important aspect mentioned by the participant was the closer connection between faculty and students. When discussing complex or nuanced topics that can be regularly found in research and academia, proximity to faculty has allowed students to ask questions and receive guidance. Additionally, having this closer relationship allows faculty to know students better, which is an important when writing strong letters of recommendation for graduate studies and internships. Letters of recommendation make up a large portion of a student's application and give potential academic advisors important information about the student, their experiences, and their past work. A strong letter of recommendation can advance a student's portfolio and grants faculty from other institutions better insight. Adding up the evidence from the testimonial, the program has allowed exposure and insight into graduate studies to the participating undergraduate students. In addition to exposure, experiences in the program such as

undergraduate research and guided courses on sustainability and resilience enhance a student's portfolio and help them in the graduate admissions process.

2.4. Promoting civic engagement.

> The fundamentals course was super cool, it was a tremendous experience because for the first time within civil engineering I was able to see different components of people in action, that is, professionals doing interdisciplinary projects. Not only electrical engineers working on electrical engineering projects but working in electrical engineering in communities or working on projects that involved the society and well for me that was super spectacular. Every week we took a class with a professor about coasts, flood management, micro-grids. We worked on what visual inspections are and it really gave a super summary or an eye-opener on how you can use the professions to work as in an interdisciplinary manner to build resiliently and sustainable which is the purpose of RISE-UP (…) if it were not for the encouragement I received from the RISE-UP advisors, I would not have had the summer experience and more so, continue to work towards publishing the knowledge learned in Food Energy and Water (FEW) systems as a method of increasing resilience in communities [13]

The RISE-UP program has provided many opportunities for architecture and engineering students to participate with community-led programs through class activities and by promoting research experiences. In the Summer of 2021, a RISE-UP student had the opportunity to participate in Disaster Relief and Resilience (DRR), an undergraduate program designed to create infrastructure projects that would bolster resilience in underserved communities in Puerto Rico. With five other students, three from the University of Illinois, Urbana-Champaign and other two students from the University of Puerto Rico (UPRM), they developed a resilience-building project in a school in a town in Northeastern Puerto Rico. Throughout the Summer, the team designed and started implementing a FEW system that included a microgrid and rainwater harvesting and treatment system.

Students that participate in RISE-UP are regularly informed through the program's faculty about research and internship opportunities, many of them becoming the students' first opportunity to apply their soft skills and technical engineering knowledge into real problems and community-based projects. By visiting communities throughout the island, students can learn firsthand through experiences, strategies, and projects that promote resilience and could be incorporated as possible options to be echoed in equivalent situations across Puerto Rico.

3. Conclusions.

We have developed RISE-UP to respond to the challenges posed by extreme natural conditions in Puerto Rico and the role that the creators of infrastructure play into developing a more sustainable and resilient environment. In reaching this goal, we have developed an academic

program that builds into already existing academic structures in our institution. We have adapted those structures to create interdisciplinary and real-life scenarios that connect students coming from traditional discipline-based curricula into experiential/interdisciplinary learning spaces.

In the process, we have also enabled spaces for servingness to be fostered. We have connected faculty and students from different Campuses and disciplinary backgrounds into situations in which students have experienced the dimensions of leadership identity, critical consciousness, research and graduate school aspirations and civic engagement. This exposure has contributed to educating students that are more engaged with their social and environmental realities, and that are empowered to act in both real and academic scenarios. Through this paper, and via the voice of former students of the program and their experiences, we have shown the positive impact that the adaptation of the traditional curricula can have on students. We have shown how the experience generated by the crossroads that the program creates between the professional interdisciplinarity, the approach to infrastructure's sustainability, and the concept of resiliency, have impacted the experience of servingness for students in the program.

4. Acknowledgement.

This material is based upon work supported by the National Science Foundation under Grants No. 1832468 and 1832427 (HSI program). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors are greatly thankful to the advisory board members and evaluators for their valuable input and feedback. We are also greatly thankful to the dedicated faculty and students participating in the project.

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