

Supporting economically disadvantaged students from Nicaragua in STEM-C fields

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Abstract—Even students who are provided with currently best available education in Science, Technology, Engineering, Mathematics and Computer Science (STEM-C) fields are having problems coping with living in the modern world where technological advancements happen on a daily basis, let alone students coming from economically disadvantaged backgrounds. In a world where institutions offering formal education have to collaborate with individuals and groups of people interested in providing informal education, it is of a vital importance to set up good examples and share them with communities that are less experienced. In this paper we present how Student Research Development Center's (SRDC) best practices of establishing a pre-college pipeline for young economically disadvantage minority students, who are interested in STEM-C fields, from Puerto Rico are being transferred to Universidad Catolica de Nicaragua (UNICA). The goal of the paper is to show how we developed a partnership between Puerto Rico and Nicaragua, and used lessons learned in Puerto Rico to involve undergraduate and pre-college students from Nicaragua in research program using project based learning in STEM-C fields.

Keywords—*informal and formal education, Puerto Rico, project based learning.*

I. INTRODUCTION

There are a lot of examples of curriculum development best practices that can serve as guidelines when planning and designing for a new formal education program [1]. However, although Science, Technology, Engineering, Mathematics and Computer Science (STEM-C) fields are said to be too wide and too complex only for formal institutions to teach them [2], there are not that many good practices shared when it comes to informal STEM-C education. Nevertheless, there is an extensive body of related work on how different individuals and group of people can contribute to the development of informal STEM-C education (e.g. [3]–[7]). In the paper we are trying to fill this informal STEM-C activity not sharing practices gap by describing one example of knowledge transfer between Puerto Rico and Nicaragua.

In order to use a best practice model from Puerto Rico for implementation of a research program that prepares undergraduate and pre-college students from Nicaragua for project based learning in STEM-C fields, we created "UNICA-Puerto Rico Alliance". This alliance represents a partnership between higher education institutions in the Caribbean and Central America and the partnerships with government agencies, municipalities, public and private high schools, professional organizations, industries, and non-profit organizations to produce an effective pipeline from pre-college to undergraduate and from undergraduate to graduate studies for minority students and persons with disabilities interested in pursuing careers in STEM-C related areas.

Since the "UNICA-Puerto Rico Alliance" is designed to impact Hispanic American disadvantaged students, it focuses on four main objectives: i) to reach and impact economically disadvantaged students from Nicaragua with Alliance activities; ii) to increase the recruitment of high school seniors in STEM-C fields through hands-on research experiences at a university setting; iii) to provide research experiences in STEM-C fields for undergraduates and pre-college students in Nicaragua and Puerto Rico, and iv) to build a partnership between Nicaragua and Puerto Rico to increase the number of graduate students in STEM-C fields and transfer 60% of BS graduates to graduate in Puerto Rico institutions.

The rest of the paper is organized as follows. In Section II we present related work, while Section III describes three institutions from Puerto Rico and Nicaragua that represent a backbone of "UNICA-Puerto Rico Alliance": Universidad Metropolitana (UMET), University of Puerto Rico, Mayaguez (UPR-M) from Puerto Rico and Universidad Catolica de Nicaragua (UNICA) from Managua, Nicaragua. Furthermore, Section IV explains which components of Puerto Rico best practice model have been selected for implementation in Nicaragua and Section V comments on results that have been obtained so far. Finally, Section VI concludes the paper.

II. RELATED WORK

Providing research experiences to pre-college and undergraduates has proven to be an educational tool that makes the undergraduate experience more effective [8]. Research has been associated with multiple benefits and has been described as instrumental in promoting a greater interest in careers in science, technology, engineering, and mathematics [9]. Students who become involved in pre-college and undergraduate research experiences are said to persist in pursuit of an undergraduate degree and specially this kind involvement helps students from underrepresented groups by increasing the retention of minority undergraduates [10]. However, most of the studies that are promoting STEM-C fields are only concentrated on one outreach activity (e.g. Kinect sensor [11], robots [12] or Arduino [13]) and are rarely focused on building pipelines [14]. In that sense, the contribution of this paper is twofold: 1) to propose a pre-college pipeline used in Puerto Rico in which students participate at different stages of their pre-college education, 2) to show how this pipeline can be used outside of Puerto Rico as well (i.e. in Nicaragua).

III. UNICA-PUERTO RICO ALLIANCE

The "UNICA-Puerto Rico Alliance" is a project designed to impact students from Hispanic American institutions in Puerto Rico and Nicaragua, including women and persons with disabilities. Its goal is to reach students within the economically disadvantaged communities in Managua, Nicaragua, through consortia with municipalities, community-based organizations, and professional or organizations like the Institute of Electrical and Electronic Engineers (IEEE). The Alliance is formed by Universidad Metropolitana (UMET), University of Puerto Rico, Mayaguez (UPR-M), Univeisidad Catfilica de Nicaragua (UNICA) and Student Research Development Center (SRDC) that is a part of Ana G. Mendez University System (AGMUS) in Puerto Rico.

UMET and UPR-M are two major institutions in Puerto Rico, with over 30,000 students offering BS, MS and PhD degrees. Moreover, both institutions have very competitive research laboratories and competitive faculty in STEM-C fields. SRDC became a model institution for excellence when received its first National Science Foundation (NSF) grant in 1985, followed by others grants totaling over 30 million USD. Finally, UNICA in Nicaragua has more than 2,000 students and offers degrees in science, law, economics and business, engineering and bio-medical.

IV. PUERTO RICO BEST PRACTICE MODEL

The development of this project follows the best practices of the Model Institutions for Excellence (MIE) program [15]. The MIE Project, which is sponsored by the National Science Foundation, enabled AGMUS to make a significant impact on the progress and success of Hispanic students in Puerto Rico [16]. Most students at AGMUS are economically disadvantaged and first-generation college students. The MIE Project at AGMUS created a pathway for science that went from pre-college to graduate school with programs that involve research at all levels. The following components of the MIE model have been selected for implementation in Nicaragua: 1) pre-college research program; 2) summer research experiences; 3) bridge to graduate school.

A. Pre-College Research Program

The MIE model is a very successful program transferring almost 100% of the participants into college with the rate of 85% of them into STEM-C fields [17], [18]. The partnership between AGMUS and public and private high schools in the Metropolitan San Juan area, built for the past thirteen years, impacted more than 2,000 pre-college students grades 10, 11 and 12 from 125 schools [19]. *Pre-college research program* is a longer-term STEM-C outreach activity that lasts for sixteen weeks during which time the mentors work with the students on a regular basis (i.e. for 4 hours on Saturdays). The mentors are responsible to implement all necessary steps of the research cycles within their specific STEM-C-related projects and help students to achieve set goals. Finally, at the end of this program students are encouraged to present results of their research at *pre-college research symposium*.

B. Summer Research Experience

Summer research experience is a research activity, used as a training ground in preparing students for graduate schools, that lasts for seven weeks and has been organized in Puerto Rico for the last six years. During the program students, who are selected out of students who successfully completed *pre-college research program* and presented their results at *pre-college research symposium*, spend on average eight hours per day, five days per week doing research-related activities under their mentor supervision. At the end of the summer experience, students have to make their posters and prepare oral presentations for the mini symposium held at the AGMUS facilities in San Juan, Puerto Rico.

C. Bridge to Graduate School

The overall objective of the project is to establish a pipeline between pre-college and undergraduate students and produce PhD degrees in STEM-C related fields. This objective is achieved through students participating in *summer research experiences* being able to take preparation courses for Graduate Record Examination (GRE) and Test of English as a Foreign Language (TOEFL). In addition to that, students participating in our program are offered help with going through the graduate school application process, taught how to write personal statements, resumes, are provided with letter of recommendations and finally are trained how to behave at interviews and how to prepare their portfolios.

V. INITIAL RESULTS

Beginning of 2015 the director of the program from Puerto Rico and the co-director from Nicaragua selected fourteen students for participation in *pre-college research program* with the equal representation of both genders. Similar to the process conducted in Puerto Rico, we were targeting students interested in STEM-C fields who had to submit a formal application together with an essay explaining the motives for their interest in the research program and plans for their future education in college. They also needed to submit two letters of recommendation, one from their school and other one from a math or a computer of science teacher. The sixteen week *pre-college research program* was followed by 2015 AGMUS-UNICA *pre-college research symposium* held on 8th of October 2015 in Managua, Nicaragua (see Figure 1).



Fig. 1. Group photograph of 2015 AGMUS-UNICA pre-college research symposium participants.

The symposium was one-day event with Dr. Juan F. Arratia presenting his talk on "Early Research Experiences, Computer Technology and Mathematics" to UNICA students and faculty members followed by a student poster and oral presentation session. The oral presentations lasted for ten minutes during which students had to present their projects. All poster and oral presentations were evaluated by scientists and the best students were awarded for their efforts. Figure 2 shows Mara Mandieta Lopez presenting her poster entitled "Design of mobile application for monitoring of earthquake events in schools in Nicaragua", while in Figure 3 Anthony Perez Altamirano is presenting his poster entitled "The Impact of Agricultural Weather Station Zones in Nicaragua".

After the first phase of the project successfully finished with the Symposium, now we are in the process of planning for the second phase in which five UNICA students will be engaged in research projects at research facilities in Puerto Rico during summer months of June and July 2016. The selected UNICA students will work in the lab every day from Monday to Friday for eight hours and will have opportunities to experience how it feels to work on their individual research projects in STEM-C fields. The duration of their *summer research experiences* will last for eight weeks during which the selected students will work with Dr. Samuel Hernandez from UPR-M and Dr. Osvaldo Cox from UMET. Both of them are world-known scientists who are passionate about preparing and training students for graduate schools. At the end of the eight weeks summer program, following the best practices of the MIE program, the UNICA students will make scientific posters and prepare oral presentations of their research projects for the mini symposium at the SRDC facilities in San Juan.



Fig. 2. Mara Mandieta Lopez presenting her work at 2015 AGMUS-UNICA pre-college research symposium.

Students who successfully finished our *pre-college research program* provided us with their feedback about the program. Due to the lack of the space, in this paper we are going to share only two students' feedback: from Mara Ethelgive Mendieta Lopez who was working on project entitled "Design of mobile application for monitoring of earthquake events in schools in Nicaragua" and Yatselt Stolichnaya Morales Mayorga who was working on a project for "Reduction of Car Collisions with the Use of Mobile App in Managua, Nicaragua" (see Figure 4). Although we present feedback from only two students, feedback from other students was also positive saying that they would recommend this program to other students.



Fig. 3. Anthony Perez Altamirano presenting his work at 2015 AGMUS-UNICA pre-college research symposium.



Fig. 4. Mara Ethelgive Mendieta Lopez on the left and Yatselt Stolichnaya Morales Mayorga on the right.

Mara said: "The experience of my years at UNICA as a PREPA student (high school) came to a high performance with the Saturday Research Academy where we had the most gratifying experience learning how to do research. The research experience gave me the tools how to search a particular subject in the Internet and libraries around the world, read scientific papers, write an abstract and design a scientific poster, as well as presenting at a symposium; also, gave me the opportunity to enhance my English because all materials are in that language, in papers, Internet and how we presented in a conference. I will strongly recommend this experience to other UNICA students."

Yatselt said the following: "Doing research at UNICA during the semester of 2015 was a unique experience. As a high school student in Nicaragua, we do not have the opportunity to develop our own projects or to develop a scientific poster. With the guideline of the research mentors, Mario Aleman, Nestor Bonilla, Luisa Mercado, and Director, Dr. Juan Arratia, the process was quite simple. I will recommend this experience to any PREPA in Nicaragua or any high school student in the Americas. I would like to thank the administration of UNICA for given us the opportunity to do scientific research. This experience will guide us in our professional life and it will be very useful for the future of our country."

VI. CONCLUSION

In this paper we presented a few activities of our Model Institutions for Excellence program and then we showed how we can use our previous experience from Puerto Rico in order to implement the same program in Nicaragua. The main objective of both programs is to fill a void within the minority student population in Puerto Rico and Nicaragua by enhancing students' opportunities to be supported by faculty research mentors, professional counselors and peers in programs ranging from career counseling, learning methodology, critical thinking, problem solving, tutoring, ethics, philosophy, logic, English language skills and orientation to graduate school.

Students participating in our programs are mostly first-generation college students who usually do not have role models and guidelines within their families and our activities provide them much more than just knowledge about how to write abstracts and papers, do oral presentations, and prepare posters. The initial feedback collected from fourteen students who finished our *pre-college research program* showed that they are very pleased with our program and that they would recommend it to their colleagues. Namely, the comments of Mara and Yatselt are samples of a mandatory feedback from the students at the end of the first cycle of the program in Nicaragua. Although we have not done the full analysis of the success rate of our program as this is still work in progress, it gives us an incentive to carry on with our work.

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