Exploring Servingness for Low-Income Academically Talented Students (LIATS) through Individual Development Plans (IDPs)

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Abstract

This paper analyzes, from a servingness perspective, the experiences of students in a Hispanic Serving Institution (HSI) implementing personalized mentoring strategies as part of an NSF-funded, S-STEM program. The program objective was to increase the retention and success of low-income academically talented students. We discuss the results of using Individual Development Plans (IDP) to help students establish post-graduation goals and action plans to reach them. The IDPs also maintained a flexible structure that allowed students for morphing both their plans and envisioned outcomes, as they progressed in their chosen academic programs. Student outcome expectations were assessed at three stages of their development: in their first year, as juniors in what can be considered a mid-point of their development, and during their fourth year of program participation.

Keywords — *Hispanic Serving Institutions, Servingness, Low-Income Academically Talented Students*

I. Introduction

Educating the new generations of science, technology, engineering, and mathematics (STEM) students continuously brings new challenges with every new student cohort admitted into a degree program in higher education institutions. On one side, the continuously increasing global demand for STEM professionals requires placing particular attention to the strategies used to recruit, retain, and bring students to successful degree completion [1]. However, STEM disciplines are ever-evolving, requiring continuous updates to keep up with sprouting technologies. At the same time, the success expectations of students also evolve as do the background experiences brought in by each recruit [2]. In the quest for increasing the number of students entering a STEM career pathway and successfully completing their degrees, higher education institutions must continuously re-invent their strategies to meet the requirements of such a complex and demanding scenario. Hispanic Serving Institutions (HSI) face additional challenges as their population includes large proportions of minority, low-income academically talented students who are often first-generation [3].

Among the myriad of strategies reported by HSIs to address such challenges, the concept of servingness has emerged as a multidimensional conceptual framework to measure a wide gamma of student success indicators [4]. The list includes academic outcomes such as retention, persistence, and graduation rates. Non-academic outcomes include self-concept, sense of belonging, leadership identity, and graduate school aspirations, among others. But servingness is a concept that is better defined by the outcomes it is designed to achieve [5]. In serving low-income STEM students, mentoring has been found to increase their likelihood of completing their studies to later pursue advanced degrees, assume leadership roles, or enter the STEM workforce [6].

This paper analyzes, from a servingness perspective, the experiences of students in an HSI implementing personalized mentoring strategies as part of an NSF-funded, S-STEM program. The Program for Engineering Access, Retention, and LIATS Success (PEARLS) had as its main goal increasing the retention and success of low-income academically talented students (LIATS) in engineering [7]. This article discusses the results of using Individual Development Plans (IDP) to help students establish post-graduation goals and action plans to reach them while maintaining a flexible structure that allowed for morphing both, plans and envisioned outcomes, as students progress in their chosen academic programs. Student outcome expectations were assessed at three stages of their development: in their first year, as juniors in what can be considered a mid-point of their development, and during their fourth year of program participation. In each case, their IDPs were reassessed with the support of their mentor to adapt to shifting students' perspectives. Aspects assessed in each intervention included students´ growth in academic self-concept, leadership identity, and graduate school aspirations. After this longitudinal experience, students indicated that completing their IDPs gave them a roadmap to follow during their college years that resulted in their participation in co-curricular activities, such as Research Experiences for Undergraduates (REUs), internships, and academic competitions, which increased their interest and confidence in pursuing graduate education opportunities or entering in a competitive way into the STEM workforce.

II. The PEARLS Initiative

The Program for Engineering Access, Retention, and LIATS Success (PEARLS) is an initiative sponsored by the National Science Foundation under the S-STEM program.

PEARLS implemented a series of strategies to address the socio-economic status (SES) achievement gap observed among low-SES engineering students with respect to their high-SES peers [9]. PEARLS, currently in its fourth year, has introduced a series of interventions organized around a theoretical framework named the LIAT College Access and Success model (L-CAS) [9]. The L-CAS model was designed to introduce a set of longitudinal interventions with objectives ranging from boosting engineering LIATS self-efficacy beliefs to propelling them into actions and immersing them into real-life contexts has resulted in a myriad of positive outcomes for PEARLS students [11]. To better understand how the servingness concept was achieved for PEARLS students, let's describe the academic setting where the initiative was deployed, the demographic characteristics of participants, and the IDP as the main instrument that enabled such an experience.

A. Academic Setting

The University of Puerto Rico Mayagüez (UPRM) is a Hispanic Serving Institution (HSI) that forms part of the eleven-campus UPR System in the island of Puerto Rico. During the current academic year, the UPRM serves 11,000 students distributed among four major colleges that include Engineering, Arts & Sciences, Agriculture, and Business Administration. With an enrollment of nearly 4,500 students, the UPRM Engineering College is the only public engineering school in the UPR System.

According to the American Society of Engineering Education (ASEE), the UPRM ranks as the top school in the nation graduating Hispanic Engineers, with a 100% service to underrepresented minorities [8]. Engineering students at UPRM are distributed among nine bachelor's-level degree programs and sixteen graduate programs that include Master's and Ph.D. levels.

Academic achievement among UPRM engineering students has for many years exhibited a persistent performance gap, fueled in part by differences in SES among students. Low-income students have been observed to exhibit up to 20% higher attrition and 18% longer time to graduation than high-SES peers. The development of PEARLS represents an important initiative to address this gap by inserting interventions, services, and context scenarios that target the development among LIATS of collaborations and interactions in communities of practice that lead to the development of practical academic and professional skills [7].

B. PEARLS Student Demographics

Students participating in the PEARLS program include undergraduate and graduate (master´s) engineering students. A total of 92 students were selected to form the study group. From these, 61 students participated as PEARLS scholars who received, in addition to the services and interventions, financial support in the form of a scholarship. The remaining 31 students were participants who benefited from all the PEARLS interventions including faculty and peer mentoring, career planning, and curricular, co-curricular, and community-building activities but did not receive scholarships. The average household family income among PEARLS scholars was $14,512/year; and $44,216/year among non-scholarship participants. Forty-three percent of PEARLS students were female. All PEARLS students joined the program in the fall of 2018. The group was integrated by four cohorts determined by the academic year that they were at the moment of joining. Table 1 lists the four formed cohorts, with the number of students in each and the proportion of the total students that each represented.

Undergraduate students were distributed across the nine bachelor's degree programs offered in the College of Engineering as listed in Table 2. The two grad students were enrolled, one each, in the Civil Engineering and Material Science and Engineering master's programs.

Table 1: Distribution by cohorts based on students' entry levels.

Cohort	Count	Percentage
1st year	34	37.0%
2nd year	29	31.5%
3rd year	27	29.3%
M.S. Grads	2	2.2%
Total	92	100.0%

Table 2: Distribution of PEARLS students by academic program

Academic Program	Number of Students	Percentage
Chemical Eng. (ChE)	14	15.2%
Computer Eng. (CE)	14	15.2%
Mechanical Eng. (ME)	14	15.2%
Electrical Eng. (EE)	13	14.1%
Industrial Eng. (IE)	12	13.0%
Software Eng. (SE)	9	9.8%
Civil Eng. (CvE)	7	7.6%
Surv. & Topog. (ST)	5	5.4%
Comp. Science (CS)	2	2.2%
Grads (M.S.)	2	2.2%
Total	92	100.0%

C. Individual Development Plan (IDP)

PEARLS induced each students to develop, in his or her first year in the program and Individual Development Plan (IDP). The usage of IDPs is a common practice among Ph.D. students and postdocs in science programs. One of the most well-known IDP tools, that served as basis to develop the PEARLS' IDP, is 'myIDP' developed by Fuhrmann, Hoin, Lindstaedt, and Clifford, sponsored by AAAS [12].

The PEARLS IDP was an adaptation of Fuhrmann's tool, aimed at inducing masters and undergraduate students to think about what they wanted to do upon graduation and establishing a plan to reach that goal. The PEARLS IDP was organized around five major sections that included self-assessment, goals, coursework, achievements, and plan. Students were asked to complete sections one through four on their own, while section five was completed in a face-to-face meeting with his or her faculty mentor. During this meeting, students had the opportunity of receiving advice on how to better lay out their plan for achieving their stated post-graduation goals. They also discussed their answers to the first four sections. After establishing their IDPs, students, revised and updated their IDPs with their mentors at least once per term. Bartolomei *et al.* offer a thorough discussion of the PEARLS IDP structure, sections, and activities in [13].

III. Servingness Indicators and Exploration Methods

Servingness is the degree to which HSIs both champion and facilitate Hispanic student success [5]. Garcia, *et Al.* indicate that

servingness can be measured through academic and non-academic outcomes [4]. Our analysis discusses two academic outcomes: retention and graduation rates. It also discusses three non-academic outcomes essential to address the socioeconomic status (SES) gap impact on engineering students. These include the development of academic self-concept, leadership identity, and graduate school aspirations [14]. The research design for this project consists of a quasi-experimental approach because it does not provide full control of potential confounding variables [15]. Instead, our analysis formulates a cause-effect relationship between the student groups formed by PEARLS students and the general population and the levels of family income of all students in the project.

IV. Discussion and Results

To mentor and develop students´ growth in academic self-concept, leadership identity, and graduate school aspirations, PEARLS mentors coordinated one-on-one meetings with students. The objective of these meetings was to have an honest discussion with the students to help them identify areas of strength and areas of improvement opportunities to achieve their personal, academic, and professional goals. Through conversation and open-ended questions, we were able to become acquainted with the students. This relationship allowed us to tailor the mentoring interactions based on students' personalities, expectations, and needs. The outcome of the initial IDP meeting was an action plan that included priority areas to focus on in the short, medium, and long term to aid students become well-rounded professionals. Periodic follow-up meetings allowed students to share with their mentor their successes and challenges towards achieving the goals set in the action plan and fine-tune future actions, as needed. Table 3 shows PEARLS student retention and graduation rates compared to the overall engineering student rates at our institution. Table 4 shows multiple examples of mentoring interactions tracked through their IDPs. These samples allow for assessing, in a qualitative way, the impact of interventions. We observe that IDPs have been particularly useful for fostering open communications with students and for monitoring their progress toward achieving their goals. It also allowed us to be on the lookout for experiences and opportunities for students. For example, knowing that a student was interested in construction engineering and in developing leadership skills allowed us to see the benefit for the student in participating in a student competition team. The mentoring intervention allowed us, as mentors, to advise the student to follow this path. Having a faculty providing encouragement to become a member of the construction competition team gave the student higher confidence, and self-assurance, while also increasing his outcome expectations from such action. The outcomes observed later on reaffirmed the servingness levels achieved for each student.

Table 3 Retention and Graduation Rate Comparison

Population	Retention Rate	Graduation Rate
PEARLS Students	97.8%	84.7%
All Engineering Students	91.2%	35.3%

Table 4: Samples of intervened students and outcomes.

Program & Student	Student observations from IDP	Recommendations provided by the mentor	Outcome
CvE Student 1	Interest in participating in academic competitions and internships. Improve my fluency in English.	Visit and explore the different student competition teams and apply to become a member. Participate in summer undergraduate research and internships.	The student participated in a summer internship with a construction company in the continental US, where he was able to practice and improve his English. He also held a leadership position in the Associated School of Construction student competition team.
CvE Student 2	Interest in graduate school	Explore universities that offer graduate degrees in areas of interest. Participate in campus visits	The student obtained scholarships to participate in campus visits and applied to graduate school. The student is currently pursuing a Ph.D. program at a research university in the continental US.
CvE Student 3	Interest in participating in undergraduate research. Improve my English.	Explore different opportunities to participate in undergraduate research both at our institution and in REUs.	The student participated in undergraduate research during the academic year. The student also participated in a REU at a University in the continental United States where she was able to practice and improve her English.
EE Student 1	Interest in the area of Biomedical Engineering Interest in acquiring research experience. Wanted to improve English fluency	Identify Biology courses to help prepare for graduate school in Bioengineering Approach research professors and apply to REUs. Spend a summer in a university or get a job internship on the mainland	The student declared a minor in biology and took preparatory pre-med school courses. She applied to REU opportunities and was admitted to one university on the mainland. From this experience, she published a poster and a paper with her REU advisor. The REU experience also helped her to improve her English fluency.
EE Student 2	Interest in developing leadership skills Interest in acquiring industry experiences	Affiliate to a student organization and volunteer to serve in the directive Fine-tune your resume and distribute it at the job fair. Create a Linkedin profile. Apply for internship and cooperative education (COOP) opportunities	The student joined a large engineering special project initiative in EE. Became the leader of the project. Attended resume preparation workshops and created PEARLS and Linkedin profiles Obtained a COOP offer in his area of interest. Later continued with a summer internship
CE Student 1	Interest in improving networking and advancing knowledge in embedded systems and cybersecurity. Wanted to practice leadership skills and develop strategies to accomplish goals	Take a leadership role in associations, attend coding club activities, take a role as an advocate to improve networking, and distribute academic workload based on priorities to have time to work on important goals.	The student has taken the role of advocate which helped him in networking with students and company members. Actively coordinated activities to develop skills of others. Has taken VP role in a student association. Learned to manage time and balance workload.

CE Student 2	Interest in developing strategies to accomplish goals. Prioritizing tasks and obligations Setting professional and academic goals.	Try industry and research activities to identify which one draws your attention. Work on prioritization. Take a lead as a Peer Led Team leader to help others.	The student undertook both research endeavors and industry experiences. He preferred working in industry, but it was a maturing experience for him as he grew professionally and personally. The student became not only a PLTL leader but the leader of all PLTL leaders. He enjoyed this role. Learned how to manage time to accomplish his capstone course successfully.
CE Student 3	Identified as needs learning about the engineering design process, experimental design, and responsible conduct of research.	Take courses in AI, Network admin, Cyber ops, and Cryptography	The student went to industry for a summer and learned a lot about system design of applications. He decided not to do research as he became passionate about fintech. He took a leadership role in a student association to improve his networking skills. He took several elective courses he intended to take.
CE Student 4	Identified as needs setting expectations and improving initiative and independence.	Consult your mentor when in doubts about setting expectations. Try to work on problems by yourself before asking for help, to develop independence.	The student consulted the mentor when applying for job opportunities, resume writing, and asked for a dry run practice for a job interview. The student obtained the job and was accepted for a full-time position with this company after graduation.
ME Student 1	Interest in competitions, improving his ME knowledge by hands-on experiences. Improving his English (writing and speaking).	Advised to participate in NASA Rover Challenge team, COOP or internships, and a leadership position in student organizations.	The student became Team Captain of the NASA Rover Challenge, presented to NASA judging board, became a certified MIG welder, and was part of a COOP experience in GE (mainland USA). He received a full-time position offer with Collins Aerospace.
ME Student 2	Research in mechanical and biomechanical engineering. Expressed passion for biomechanics. Wanted to learn more about materials, COOP, and present at a conference.	The student was advised to apply to REU's in his field of interest, also he was advised to work on his Capstone in his area of focus.	The student was able to work his Capstone with me as advisor, his work was extraordinary. Furthermore, he applied to four REU's and was accepted on all of them, he participated in one experience researching on his area of interest. The student was accepted to the U. of Michigan Ann Arbor Ph.D. program in ME.
ME Student 3	Interest in project management, manufacturing, and medical devices.Interest also in statistical analysis, internships, data interpretation, and research skills.	The student was advised to participate in student organizations and to apply for opportunities in industry. Her major interest was in manufacturing.	The student far exceeded all her goals. She received three fellowships, including AIMCO Cares, Sartorius Stedim Biotech, and Academic Excellence Grant. She became member of the We Engineer Program, and Peer Mentor. She was a COOP in AMGEN.
IE Student 1	Identified as needs to overcome the fear of publicly speaking.	Take the courses INGL 3250 - Public Speaking and INGL 3236 Technical Communication	The student improved her oral and written communications skills and she has been able to present professional work and has written the final reports of her projects with very few corrections.
IE Student 2	Identified as needs developing project management skills.	Register to complete the project management minor.	The student is completing a Minor in Project Management in addition to her BSIE.
IE Student 3	Identified as needs to learn about ethics in a work environment.	Take the courses FILO 3155 - Introduction to Ethics and FILO 4045 – Ethics in Engineering.	The student has a broad understanding of the norms that direct or value human behavior in society and in the work environment.
IE Student 4	Identified as needs to improve research skills.	Take the courses INTD 3355 – Research Methods in Libraries and ININ 4998 – Undergraduate Research	The student graduated from the UPR IE program and currently is completing a doctoral degree at the University of Wisconsin in Madison.
ChE Student 1	Interest in participating in an organization dealing with nuclear energy or material science. Interest in undergraduate research and COOP experience.	Explore student chapters and apply to become a member. Participate in summer undergraduate research and COOP.	The student joined the UPRM chapter of the American Nuclear Society. First was the treasurer of the Board of Directors and currently is the Vice President. Is a team member of the NASA RASC-AL Propellant & Resource Acquisition Team (PRAT). Participated in the NSF CISTAR REU. Was a Coop student at Eli Lilly and did an internship at Mondelēz International.
ChE Student 2	Interest in undergraduate research, industrial experience, and graduate studies.	Participate in undergraduate research at UPRM, apply to REUs, apply to internships, compete for fellowships and apply to graduate school.	The student participated for almost three years in undergraduate research at UPRM in three research groups. Participated in two REUs at Stanford and at the University of California, Berkeley. Participated in two internships with Merck and with ExxonMobil. Was awarded the National Science Foundation – Graduate Research Fellowship. She is currently a graduate student at Stanford University.

V. Conclusions

The PEARLS project has been successful in serving our students as evidenced in the academic and non-academic outcomes of servingness. PEARLS students have significantly higher retention and graduation rates than the overall engineering student population at our university. The use of IDPs and periodic meetings with their mentors have resulted in improved academic self-concept among PEARLS students. Students have shown growth in their perceptions and actions related to setting and achieving academic goals. We have also been able to serve our students by developing leadership identity through curricular and co-curricular activities including participating in academic competition teams and taking leadership positions in student chapters of professional associations. The PEARLS program has also been successful in fostering graduate school aspirations as evidenced in the number of students who opted to continue to pursue master's and Ph.D. degrees, observing that many of them are first-generation students, who are opening avenues for others to follow their lead.

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