Impacting Students from Economically Disadvantaged Groups in an Engineering Career Pathway

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Work in Progress: Impacting Students from Economically Disadvantaged Groups in an Engineering Career Pathway

Abstract

This work in progress describes the overall initiative in the program for engineering access, retention, and low-income-student success. It discusses the program structure, implementation of activities, outcomes for the first of five years of project, and reflections on our initial findings.

Introduction

The Program for Engineering Access, Retention, and LIATS Success (PEARLS) was established with the objective of increasing success statistics of low-income, academically talented students (LIATS) in the College of Engineering (CoE) of the University of Puerto Mayaguez, a Hispanic Serving Institution. CoE-level statistics for 2015 revealed that students from households with income above $50,000/year exhibited 73% graduation rate, while those from families with income below $7,500/year graduated at a 54% rate. Similar disparities were also observed in retention and persistence rates for these groups, with a marked higher attrition among students in the lower income bracket.

In an attempt to impact these trends, PEARLS established an intervention model that integrates elements from Lent's et al. Social Cognitive Career Theory [1] and Tinto's Departure Model [2], coupled with a scholarship program aimed at mitigating LIATS economic hardship. The resulting model included tools for reinforcing academic performance, faculty mentoring, extra-curricular activities, peer group support interactions, and research/work experiences.

A pilot group of 92 students from ten different engineering programs and four different entry levels, joined the project. At the end of the first year indicators shows encouraging preliminary results. 97.9% students in the study group performed above the college-wide average. Freshmen success indicators in terms of academic performance, retention, and sense of belonging were up and career goal planning and actions began to show.

Background

Success in higher education institutions by itself is a subjective concept that depends on the metrics defining it. Factors such as retention, quality, completion, and attainment are typically addressed by many institutions [3]. College completion is almost universally agreed as a success metric. It requires retaining students who persist making steady progress towards graduation.

Much attention has been devoted to attrition, a phenomena that, when mitigated, contributes to student success. Models such as Spady's Conceptual Work on Attrition [4]; Tinto's Institutional Departure Model [2],[5]; and Bean's Student Attrition Model [6] are widely known. These early models spawned a large number of studies shaping a significant portion of today's knowledge on the factors defining attrition. Further studies have addressed different perspectives of the historical evolution of attrition factors in the U.S. and abroad [7] [8] [9].

Several studies have looked into particular factors affecting the success low-income students. Thayer summarizes salient works related to the retention of low-income, first-generation students

[10]. His writing highlights the gap in degree completion rates between students from top and bottom income families and the hurdles faced by first-generation students in four- and two-year institutions. Other studies have specifically addressed factors affecting low-income students in STEM fields, particularly in engineering, linking the causes of attrition to diverse factors, among which, the increasingly higher net price of engineering education tops the list [11], [12]. Economic burden not only deters low-income students from entering STEM majors. Cole and Espinoza remark that Latino students from lower socioeconomic levels have a higher chance of facing cultural incongruences in a middle-class university environment, negatively impacting college persistence [13]. Little formal work has been found on this subject for either the host institution student population or at the state level. A study by Miguel et Al. found that local low-income students had, in general, higher failure rates in portal courses, less participation in programs with higher entrance requirements, higher attrition, and lower graduation rates in STEM programs than non-low-income students [14]. Figueroa-Flores studied the effect of hybrid courses in local student attrition [15]. Statistics tracked by the local Education Council point to a state average graduation rate of 37.4% among local public and private 4-year universities [16]. These works denote that despite the large number of initiatives on student success, attrition, and retention; disparities continue to exist and new approaches addressing low-income engineering students in their particular educational setting are still needed.

The LIAT College Access and Success (L-CAS) Model

The L-CAS is a hybrid model that combines elements from Lent's et al. Social Cognitive Career Theory (SCCT) [1] and Tinto's Departure Model [2], framed by a scholarship program aimed at mitigating the economic hardship of engineering students in the University of Puerto Rico Mayaguez. Figure 1 provides a conceptual view of the L-CAS model.

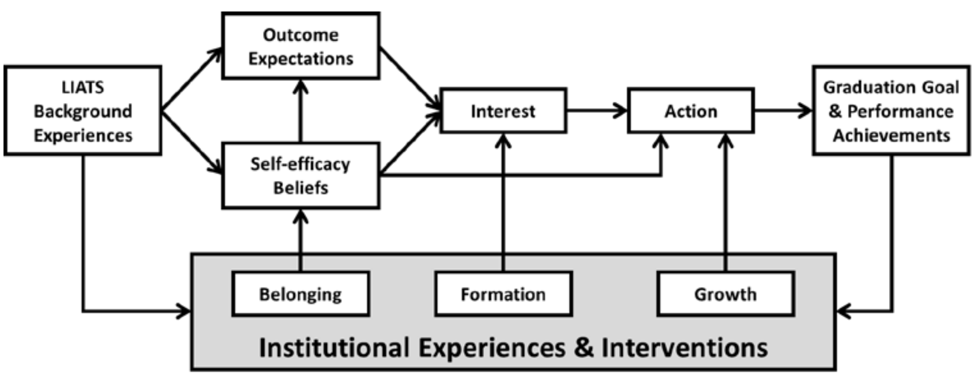

Figure 1: LIAT college access and success model.

The rationale for combining elements from the said models lies in two factors: first, SCCT is able to provide insight into the individual's career choices, development, and adjustment in educational and occupational pursuits [17], [18], [19]. It provides an understanding of how self-efficacy, expected outcomes, and goals interact with social, contextual, and experiential factors. Second, Tinto's departure model (DM) has the ability of dealing with institutional factors, helping to understand why students leave [20]. The L-CAS model is primarily interested in understanding what makes engineering students succeed. It adopts the way Tinto's DM incorporates personal traits, institutional commitments, and background experiences to shape interventions aimed at impacting SCCT factors and studying their effect on LIATS success.

Success in our case is defined by the student ability to complete an engineering degree within 133% of the nominal program time and inserting into the grad school or the engineering workforce during the first-year post-graduation. Metrics to measure students' advancement towards such a goal include retention, time-to-graduation, completion rates, and post-graduation choices.

The main question driving this research is: How effective is the L-CAS model at improving engineering LIATS success as a consequence of developing awareness of their career paths, improving self-efficacy beliefs, developing leadership skills, and going through a sequence of courses designed to develop soft skills for engineering research and practice? Metrics such as retention, persistence, and self-efficacy beliefs, among others will be measured longitudinally using institutional statistics, performance reports, self-report surveys, and validated instruments such as that developed by Lent for self-efficacy [1].

The L-CAS Components

The L-CAS model includes four major components: Background Experiences, Belonging, Formation, and Growth. Each component includes interventions designed after successful practices cited in the literature and credited to impact self-efficacy beliefs, persistence, and academic success.

The *background experiences* component takes into consideration socio-demographic and family variables identified to affect student's self-efficacy beliefs and outcome expectations [1].

The *belonging* component includes a set of activities to develop professional identity and sense of belonging. Activities such as establishing learning communities through project-oriented engineering teams, aim at developing freshmen and sophomores' interactions with senior students via capstone and design-oriented courses. These interactions are structured around two one-credit courses, Introduction to Engineering (INGE-3001) and Introduction to Learning Communities (INGE-3002).

In the *formative* component, interventions in the form of talks and soft-skill workshops are aimed at training students using well-known high-impact educational practices [21]. Trainings based on the Affinity Research Group (ARG) model [22] were arranged into a variable credit, elective "Undergraduate Seminar" course (INGE-3003). This stage also incorporated an embedded librarian [23] to help students develop introductory researcher's skills, such as search, retrieval, classification, plagiarism prevention, and scientific literature selection, offered as an elective "Literature Research" course (INTD-3355).

The *growth* component seeks springing LIATS into actions by participating in undergraduate research (UR) and/or Co-op/internships in industry. This stage allows for students tuning their formation for competitively entering either graduate school or the engineering workforce. Students returning from UR or industry experiences can join a group of peer leaders helping newcomers create awareness about their careers. Growth activities also serve as a transitional stage for LIATS moving onto the graduating level. This last level supports student choice of grad school, the engineering workforce, or entrepreneurship by providing guidance in applying for graduate scholarships, writing research statements, managing a portfolio and having top-notch resumes according to their areas of interest.

A key element for the L-CAS model functionality is a mentoring component where each student is assigned a faculty mentor from his or her own study program. Faculty mentors complement the work of academic and professional counselors by providing individualized attention to students and offering them guidance and support for their professional growth.

Two major tools allow mentors to individually track students: a contact relations management (CRM) system and individual development plans (IDP). The PEARLS CRM provides a centralized platform for tracking student progress in different project areas. IDPs provide for a personalized tool to identify students' strengths and weaknesses, set goals, and outline a plan to reach those goals. The PEARLS IDP was developed using the National Institute of Health Ph.D. IDP form as a model and using SACNAS guidelines for undergraduate IDP adoption [24]. IDPs have five sections that include self-assessment, career goals & planning, coursework, achievements, and action plan. Students discuss IDPs with their mentors at least once per semester to ensure updated alignment with career goals.

The PEARLS Study Group

The selection process for PEARLS students included data from official documents, background variables, economic need (FAFSA), and structured individual interviews. As a result, 92 students, from a pool of 871 applicants were selected: 41 (39 undergrads and 2 grads) received scholarships becoming 'Scholars' and 51 were incorporated as 'Participants'. Table 1 provides a distribution of undergraduate PEARLS students. The two graduate scholars included one in civil engineering and one in engineering materials.

The distribution in Table 1 shows that 43% of the sample were females and the percentage distribution of students according to academic year was: 37% freshmen, 31% sophomores, and 30% juniors. The weighted yearly average household income of scholars was $14,512, while that of participants was $44,216. Based on the scholarly level of parents, 21.7% were first-generation students. In addition, 63.4% scholars were from rural areas, while 53% participants were from urban areas. Overall, 70% came from public schools.

Table 1: Distribution of undergraduate PEARLS students

Program	Gender		Year			Total	Program	Gender		Year			Total	Program	Gender		Year			Total
	M	F	1st	2nd	3rd			M	F	1st	2nd	3rd			M	F	1st	2nd	3rd	
Electrical	12	1	5	4	4	13	Industrial	6	6	4	5	3	12	Surveying	1	4	2	2	1	5
Computer	9	5	5	4	5	14	Chemical	6	8	5	5	4	14	Comp. Sci.	2	--	--	--	2	2
Mechanical	8	6	5	4	5	14	Civil	2	5	3	2	2	7	SW Eng.	6	3	4	3	2	9

First-year Results and Analysis

Four indicators of student progress towards project objectives were assessed: first-year retention, sophomores' and juniors' persistence, average GPA per student level, and credit approval rate (CAR) for their designated study year. Table 2 lists the data associated to these indicators for our study group and for those in the general student body in the CoE, used as a reference.

Retention among PEARLS freshmen was found to be 5.6% higher than the ten-year college-wide average. Persistence of PEARLS sophomores and juniors, measured in terms of re-enrollment for their next study year, was 25.3% higher than the ten-year college-wide average. GPA and in-program progress comparisons were made with respect to engineering students in the same cohorts as the study subjects. The comparison base included 776 freshmen, 704 sophomores, and 624 juniors taking courses in the academic year 2018-2019. First-, second-, and third-year PEARLS students were found to have average general GPAs 26.1%, 32.6%, and 42.0% higher than those in the respective comparison groups. In terms of progress towards graduation, assessed by the CAR, PEARLS freshmen exhibited virtually the same progress as their peers, with only 1.2% higher CAR. Among sophomores and juniors, the CAR exhibited wider differences, with PERALS students showing 15.0% and 19.6% higher rates than their peers.

Table 2: Early Indicators of progress towards project objectives.

Indicator	PEARLS (2018-19)	Comparison group
Freshmen retention	97.1% (33 out of 34)	91.97%*
Returning sophomores' and juniors'	100% (56)	79.8%**
Average General GPA for 1st/ 2nd/3rd year students	3.27/3.46/3.45	2.95/2.61/2.43***
Credit Approval Rate in % for 1st, 2nd, & 3rd year students	91.2/93.7/90.8	90.1/81.5/75.9***

* CoE (2007-2017) **CoE (2005-2015) ***CoE average GPA 2018-2019

Participation of PEARLS students in program activities was significant. By year-end, 74% (68) students had completed and discussed their IDPs with their respective faculty mentors. A total of 56 (61%) reported applying to summer experiences and 10 students plus one non-affiliated volunteered and were trained to become mentors of their peers. Participation in most program elective courses was also high: 77.8% (28/36) in INGE-3001, 55.6% (20/36) took INGE-3002, 82.1% (23/28) in INGE-3003, and 21.4% (6/28) in INTD-3355. Participation in professional growth talks and workshops was high as well, with average 74.3% attendance to 7 workshops offered as part of the program. Further analysis is needed to determine the impact of specific workshops and courses on the measured indicators and registered actions.

Conclusion

First year results in the presented work suggest that early structured interventions seem to impact progress and professional readiness in participating students and their future career plans. Longitudinal results will allow us to determine the impact of the various L-CAS model components on the academic performance of engineering LIATS, self-efficacy beliefs, and students' success. Although the small sample size in our study will limits us in generalizing our results, the statistical analysis of longitudinal data, will yield sufficient evidence to demonstrate areas of success to consider implementing at a larger scale. It is our expectation to maintain, in the years to come, the encouraging results observed in this first year.

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