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Work in Progress: Building Career Goals and Boosting Self-efficacy in Engineering Students

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Her research interests include investigating students' understanding of difficult concepts in engineering sciences, especially for underrepresented populations (Hispanic students). She has studied the effectiveness engineering concept inventories (Statics Concept Inventory - CATS and the Thermal and Transport Concept Inventory - TTCI) for diagnostic assessment and cultural differences among bilingual students. She has also contributed to the training and development of faculty in developing and evaluating various engineering curriculum and courses at UPRM, applying the outcome-based educational framework.

She has also incorporated theories on social cognitive career choices and student attrition mitigation to investigate the effectiveness of institutional interventions in increasing the retention and academic success of talented engineering students from economically disadvantaged families. She's also involved in a project that explores the relationship between the institutional policies at UPRM and faculty and graduate students' motivation to create good relationships between advisors and advisees.

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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 dielectric applications and as biocides. More recently, through a grant from the US Dept. of Agriculture, he has been working on the structural and mechanical characterization of an invasive wood to Puerto Rico. Important components of his interests are education and outreach to underrepresented minorities.

Building Career Goals and Boosting Self-efficacy in Engineering Students (Work in Progress)

Keywords: individual development plan, college success, mentoring

Abstract

This work in progress presents the development and implementation of an Individual Development Plan (IDP) for undergraduate and first-year master's engineering students. The IDP was designed and tailored as one of several strategies to increase retention and graduation rates for engineering students participating in the Program for Engineering Access, Retention, and LIATS Success (PEARLS). This program provides scholarships to low income, academically talented students (LIATS), and promotes their academic success and on-time graduation. We show how the IDPs, paired with a faculty mentoring component are able to produce a powerful mechanism to boost LIATS actions, propelling them to become highly competitive engineering students.

Introduction

Low-income students have been found to traditionally fall among groups with marked attrition, longest time to graduate, and reduced persistence indexes in many higher education institutions [1], [2]. Although many non-academic factors have been linked to this trend and numerous approaches reported to address the problem, its incidence continues to create a success gap between this group and the general student population.

This reality has not been an exception in the Engineering School of the University of Puerto Rico Mayaguez (UPRM), a Hispanic serving institution (HSI) feeding one of the largest shares of Hispanic engineers to the US labor market [3]. Over 70% of the engineering student body in UPRM come from economically disadvantaged families [11], and exhibit gaps with up to 20% higher attrition and 18% longer completion time than counterparts coming from less economically disadvantaged groups.

In an attempt to close this gap, the College of Engineering started in 2018, with the support of the National Science Foundation (NSF), the Program for Engineering Access, Retention, and LIATS Success (PEARLS).

Since its inception, PEARLS has impacted students from several cohorts with a set of interventions with the common goal of increasing the level of success of engineering LIATS. One of the intervention mechanisms has centered in driving students to establish early in their academic lives, a roadmap of their school path as students, looking into their objectives as graduating engineers. The mechanism used for such an objective has been an individual development plan (IDP) specifically tailored for undergraduates and first-year graduate students, complemented with a faculty mentoring program.

The main research question driving this initiative is identifying how the exercise of bringing such a tool to early study program engineering LIATS in an HSI could impact their success indicators and understanding the IDP influence in the mentor-mentee relationship.

This paper presents the process of developing the PEARLS IDP, preliminary results obtained from its implementation on PEARLS participants during the first two years of the program, and mentors' perceptions on the effectiveness of such a tool. The rest of this manuscript describes the academic setting and the structure of PEARLS; an in-depth description of the PEARLS IDP; how the IDP was initially administered to students and the preliminary results obtained from such an exercise, as well as the mentor's perceptions on their participation in the process. Finally, we discuss the lessons learned through this process and how they are shaping future interventions in the program, to finally finish with concluding remarks.

Academic Setting and PEARLS Program Structure

The University of Puerto Rico Mayaguez is a Hispanic Serving Institution (HSI) best known for its engineering school. The UPRM, according to the American Society of Engineering Education (ASEE), ranks within the top three schools in the nation graduating Hispanic Engineers with a 100% service to underrepresented minorities [3]. With an enrollment of 13,148 the UPRM boasts a vibrant campus where 36% of its student body are engineering students, distributed among nine bachelor's level degree programs. According to the UPRM Office of Economic Aid, approximately 70% of students qualify for Pell grants.

PEARLS Organization

The PEARLS program is organized as a hybrid intervention model, named the LIAT College Access and Success (L-CAS), that combines elements from Lent's Social Cognitive Career Theory and Tinto's Departure Model, and complemented by a structured scholarship program that addresses engineering students from disadvantaged socioeconomic groups [4]. The L-CAS model provides a series of longitudinal interventions distributed in its stages of background experiences, belonging, formation, and growth, designed to impact the self-efficacy beliefs, persistence and academic success of low-income students. Early in the model, students are encouraged to begin planning for their future as maturing engineering students and uprising professionals. A key element for this plan is the completion of an individual development plan (IDP) specifically tailored for undergraduates and first-year master's level students.

Recruitment of Participants

The recruitment of program participants was carried-out in five stages: Invitation, Solicitation, Informative Session, Interviews, and Selection. All undergraduate engineering students from first to third year and all first-year master's students were informed of the program opportunity and were encouraged to apply, reaching-out to 2,388 potential applicants. A total of 871 students applied, and were summoned for an informative session to provide them with detailed program information and what to expect during the selection process. The info-session was attended by 628 students who were asked to provide additional as the next selection stage, a step completed by 564 applicants. The collected student information was evaluated to assess economic need, academic performance, and involvement in activities. This resulted in 136 candidates invited for interviews, from which 92 were selected to enter the program.

Participant's Demographics

From the initial group of selected students, 41 (39 undergraduates and two master's level grads) were awarded with scholarships, and 51 were accepted as participants with no economic aid. Scholars came from families with average household income of $14,512, while participant's families' income averaged $44,216. Gender-wise, the group featured 43% females. The group included first-, second-, and third-year students distributed as 37%, 31%, and 30%, respectively. In terms of engineering study program, students were distributed as 14% in electrical, 15% computer, 15% mechanical, 13% industrial, 15% chemical, 7.6% civil, 5.4% surveying, 2.2% computer science, and 10% software engineering.

Mentor Assignments

Students were distributed among eight faculty mentors, according to their study discipline. The programs of civil engineering and surveying shared the same faculty mentor, as did the computer science and software engineering programs. The eighth mentor was assigned to the master's level graduate students. All faculty mentors participated in talks and workshops where they were given information about effective academic mentoring, how to refer students to academic and professional counseling services, and how to deal with stressful and difficult situations.

The PEARLS IDP

The Individual Development Plan is one of several strategies of the PEARLS program designed to motivate students towards achieving success and for moving them forward on their career path to become professional engineers or pursue graduate studies. The use of IDPs has become a best practice with Ph.D. students and postdocs in science programs. One of the most well-known IDP tools is 'myIDP' developed by Fuhrmann, Hoin, Lindstaedt, and Clifford [5], [6] and sponsored by AAAS. In fact, it was this work what inspired us to create the PEARLS IDP. We also considered the work of Bosch [7], which specifically focuses on IDPs for undergraduate students.

The benefits of completing an IDP have been widely accepted. Such is the case that in 2012, the U.S. National Institutes of Health (NIH) Biomedical Research Workforce Working Group required IDPs for their postdoctoral researchers (Austin) [8] and the National Science Foundation included the IDP as one of the tools in their career development website [9]. As we can see, both NSF and NIH, as well as many universities, have embraced the IDP as a key component for enhancing STEM graduate and postdoctoral programs. In fact, in studies of reflection as pedagogy the IDP is considered a self-reflection tool. Researchers such as McMillan and Hearn have reported that it enhances self-motivation and achievement [10].

Taking all these factors into consideration, and the fact that there is not a similar tool as 'myIDP' for undergraduates, we developed an instrument customized to fit the goals of bachelor's and master's level engineering students.

The first version of the PEARLS IDPs were developed during the first semester of the program (Fall 2018) and the students were instructed to complete the forms during the next semester (Spring 2019). The process of completing the IDPs extended throughout fall 2019. At the time the results were tallied, four participants had left the program, reducing the study group to 88 students. Completing the IDP was entirely voluntary for all students.

Form Structure

The PEARLS IDP was organized around five major sections: self-assessment, goals, coursework, achievements, and plan. Students complete sections one through four on their own. Then, through a face-to-face meeting with their mentors, students are guided to complete section five. The description for each section follows.

1. *Self-Assessment*

In the first IDP section, students are required to self-assess their perceived levels of performance with respect to their peers' in six major areas that include: Knowledge, Research & Technical Skills, Communication, Management Skills, Mentoring, and Professionalism. An extra block is included for students to report any other skill that they need to work on. A five-point scale, ranging from Very Weak to Strong is provided for their assessment and a check box to identify target skills to work on during the following year. The goal of this section is to guide students through an auto-evaluation process of strengths and weaknesses.

2. *Career Goals & Planning*

Here, students are asked to declare short-, medium-, and long-term academic goals and delineate specific actions to be taken for each goal set, as well as potential barriers that could prevent them from reaching the established goals. They also express what they foresee as their career setting, whether as researchers, as educators in academia, or as professional engineers in practice. This section drives students to visualize themselves as future engineers, considering the different professional paths they could choose. This exercise is fostered by the students' exposure to the different areas of professional exercise through the course *Introduction to Engineering*, offered as part of the PEARLS program.

3. *Coursework*

In this section students are asked to identify elective courses that they consider will contribute to their future career goals and plan when they will take them. Students are also asked to include their plans for undergraduate /graduate research courses and/or COOP/Internship. This IDP part leads students to think ahead on the benefits of elective courses towards the achievement of their personal goals.

4. *Achievements*

This section serves to assess students' yearly achievements which include: course products, publications & presentations, received fellowships or awards, seminars, workshops, professional development activities, teaching or tutoring, community service, and leadership/outreach experiences. The goal of this section is to track students' achievements during their path to graduation.

5. *Action Plans*

This section is completed with the aid of the student mentor. Mentors review the students' answers in sections one through four during a scheduled meeting. During this meeting, the mentor discusses with the students' future plans and provides recommendations to ensure the action plan delineated by the student is achievable and properly aligns with the student expressed objectives. This way of completing the IDP reinforces the student-mentor relationship and strengthens the mentor's individualized knowledge of his or her mentees.

Administering the PEARLS IDP: Procedures & Results

Students and mentors were introduced to the purpose and value of the IDP before starting the process of its administration. Topics included the purpose of the IDP, its intended effect, corresponding roles, and how to complete it. A checklist of activities to guide both the mentor and the mentee during the process was distributed as a guide. The two PEARLS faculty who worked in adapting the forms delivered the presentation.

The first IDP version was administered to students as an Adobe form. Each faculty mentor was given the task of following-up with their mentees to collect the completed forms with answers in sections one through four, and create appointment slots with their students for its discussion. During this meeting, mentors and mentee designed an action plan corresponding to section five of the IDP. Mentors stored the completed IDPs in a Customer Relation Management (CRM) system for future reference. Students were also given a copy of the completed IDP for their follow-up. The IDP follow-up plan contemplated periodic revisions with their mentors, at least once per year.

Student Responses

The student response rate to completing the IDP process, including the discussion with their respective mentors, was 90% (79 out of 88). In a survey administered to students after completing their IDPs, 53% of them (42 of 79) expressed to "strongly agree" or "agree" that the IDP was a useful tool, while only 48% (38 of 79) considered it was easy to fill out. The student's perception of the interaction with their mentor was considerably good as 66% of respondents (52 of 79) indicated that their mentors had been helpful in completing their IDPs.

To deepen into the students' perceptions of the mentoring experience, they were asked to evaluate the process as well as their mentors. Responses were overly encouraging, as 82% indicated they had established a positive relationship with their mentors, 85% responded that their mentors provided them with helpful feedback and positive criticism, 83% considered their mentors were easy to approach and talk to, 82% indicated they received timely feedback, and 76% reported being encouraged to apply to summer research programs, cooperative education, or industry internships.

Students also reported to be 'Very Satisfied' or 'Satisfied' with the following aspects of their mentoring experiences: the way their mentor treated them (87.50%), the communication approach toward them (84.37%), the structure or organization of the meetings (75%), the performance standards established by mentors (79.68%), the relationship established (78.12%), the style of mentoring (76.56%), and the written plan that included goals to be met under their mentors' guidance (70.31%).

When opportunities opened during the next job fair, research opportunities, and other initiatives, we noticed an increased enthusiasm among PEARLS students. A total of 47 students participated in summer research experiences, 33 on-campus and 14 in off-campus REUs. The participation in industry experiences was also significant, with twelve students joining STEM-related jobs while other twelve joined special projects, student association initiatives, and team competitions.

Mentor's Feedback

Mentor's impressions of the IDPs were also assessed via a brief questionnaire administered at the end of the first year of the program. All eight mentors completed the questionnaire. When prompted "*The IDP is a useful tool for mentors*", 87.5% (7/8) either agreed or strongly agreed with the statement, with one mentor who neither agreed or disagreed. When prompted "*I encouraged students to complete their IDPs*", again, 87.5% agreed or strongly agreed and one provided a neutral answer.

Assessment and Adjustments

Many students expressed that they considered the form difficult to complete. From this feedback, we understood that a simpler form would be beneficial. Consequently, we engaged in the process of re-evaluating the form to identify redundancies, reduce open answers, and consolidate related questions. This exercise resulted in a form that was 25% shorter than the previous version. Moreover, the revised IDP contemplated facilitating the follow-up to previously completed forms, while maintaining the requirement of face-to-face interactions with mentors for completing section five.

Before exporting the form to a new platform for administering it to students, mentors were asked to evaluate the recommended changes. Six of eight mentors (75%) 'Agreed or 'Strongly agreed' that the revised version of the IDP was easier to complete, while two felt it maintained the same complexity level.

The plan to update and distribute the IDPs was hindered by a string of events occurring at the beginning of 2020. First, in January, a 6.4 earthquake and subsequent aftershocks delayed the start of the spring semester by three weeks. Shortly after classes started, on March 14, the lock-down response to the Covid-19 pandemic shut the university down, resuming activities two weeks later exclusively through online interactions. Consequently, the IDP form itself had to be reassessed to transform it into an online form and virtual follow-up of students.

Lessons Learned and Ongoing Work

Aside from the inconveniences caused by the earthquakes and the pandemic, the IDP experience was not trouble-free. Although both, mentors and students, received training on how to complete the IDPs, both groups faced problems during the process. We found that some students completed their IDPs in print and scanned the completed form to report their answers instead of using the Adobe form. Other students emailed their forms while a few submitted them in paper in the mentor's office. This unexpected turn fostered face-to-face interactions with mentors, but at the same time made difficult IDP tracking and record keeping. When we inquired about the reasons for not using the provided form we found that even when students were expected to use personal computers to complete the form, most of them used their cell phones instead, causing compatibility problems with the forms. These reports, among the limitations imposed by the pandemic, made us aware that there was a need to revise the IDP, consider an alternate form, and straighten the administration process. As a response, a new, fully on-line IDP is being developed, one that allows for virtual interactions with students. Training schedules for students are now being planned through peer-mentoring to capture student trends in following-up with the virtual IDPs. Mentors will be trained separately to try to reach an even higher response for students, and strict document management strategies established to prevent deviations from the established data collection formats.

Despite the setbacks, students completed their IDPs, the communication between students and mentors was reinforced, and students went through the process of establishing their first IDP. Mentors reported a positive experience in communicating with students via the IDPs, as well as students communicating with mentors. Moreover, as many as 80% students actively participated in summer experiences, while academically excelling at rates that surpass the average student.

These results, although preliminary, shed light into the answers sought for our research, indicating that IDPs provide the ground for defining a student base-line across different aspects of their education. Once a self-assessment is established, and the specific goals are clear and concise, the student is better equipped to identify the path forward to accomplish those milestones in their career, enabling the guidance from their mentors, and creating opportunities for actions that place them above the average student.

Conclusion

We have presented the implementation of an individual development plan tailored for undergraduate and first-year master's students. The customization process to allow the IDP to be useful with undergrads was discussed, as well as the implementation process. Results indicate that students and mentors alike consider it a valuable tool. Moreover, the actions taken by students denote impact in the direction of leading them to become competitive engineers, with accumulated experiences in research, team working, and industry experiences. This group, despite coming from economically disadvantaged families, is making excellent progress towards closing and surpassing the traditional gap that separates this group from the rest of the student body. Meanwhile, as part of our ongoing project, we have identified strategies that work and opportunities for being more effective in our quest to help our LIATS become successful engineering students.

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