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Implementing Technological Tools and Best Practices for Student Academic Success in STEM+H Careers

García-González, Rolando [1] and Martínez-Rolón, Lilliam [2]

[1, 2] Universidad del Turabo of the Ana G. Méndez University System (AGMUS)

Abstract

Both implementation of best practices and appropriate technological applications can help bridge gaps that college students face on a daily basis. Highly successful peer tutoring and faculty training programs have been implemented in order to prepare students to thrive in an increasingly technological world, as well as prepare faculty members who will be able to help students master academic standards and skills. The creation of a web space for increasing the accessibility of academic support programs and an increased presence in social media platforms to engage students in an interactive format, as well as fine tuning the offerings and their availability, have reaped great benefits, making more robust existing academic support initiatives. Also, the establishment of a revamped Summer Faculty Immersion Program, which has proven highly effective in the School of Engineering (SOE), has been transformed and exported to other schools, providing additional tools for both regular and adjunct professors in STEM+H careers. This paper describes how outstanding initiatives from two different projects have allowed the growth of faculty training and academic support programs for a vast majority of students from the Universidad del Turabo (UT) and its five centers in Puerto Rico to increase retention and graduation rates.

Keywords: peer mentoring, tutoring, academic support services, STEM, faculty development, student retention, graduation rates, STEM+H

Introduction

Low rates of student retention and college completion are a persistent problem in the United States and Puerto Rico (Calderón, Báez and Rivera, 2015). Some students come with inadequate academic preparation, job duties, family responsibilities, or worse, not intellectually or cognitively ready for the challenges faced in college (Feldman and Zimbler, 2011). Unfortunately, when students begin to struggle and no effort is made to address the reasoning behind it, achieving academic success will become harder and they may eventually choose not to continue with their academic goals (Acosta, 2013). Studies have shown that achieving academic success is beneficial for students and university, as well to society as a whole (Martínez, 2014). Organizational variables include the need to have a variety of programs to meet the needs of different types of students and provide meaningful involvement for faculty, staff, administrators, parents, and students (Wilson, Cortter, Lunnen, Mallory, & William, 1999). Of these variables, two of the most relevant are faculty capacitation and the academic support systems available.

Comprehensive efforts to strengthen support services for the science, technology, engineering, mathematics, and health sciences (STEM+H) student population are critical, and retaining college level STEM+H students remains a priority in higher education. A variety of methods have been shown to increase retention, but these efforts are not enough to graduate a large enough workforce in STEM disciplines compared with other countries (Gereff, Wadhwa, Rissing, & Ong, 2008). Student's background characteristics like family background, precollege schooling, low academic performance and personal needs, among others present a challenge for STEM programs. In fact, about half of students who left STEM majors switched to non-STEM majors before graduation and the other half left college without obtaining a degree (Chen & Soldner, 2014). To help increase the number of students passing courses with high failure rates and reduce dropout rates, institutional efforts need to focus on academic and social integration.

For the past several years, Universidad del Turabo (UT) has developed various initiatives to address student academic deficiencies by placing them in basic, developmental courses. Retention rates of the freshmen cohort have improved; however, there is an existing need to provide STEM students with sufficient academic support services to improve their academic achievement and successful course completion. Poor retention of undergraduates in STEM majors is a common challenge in many institutions. Through the TV STEM Engineering (USDE #P031C110050) and TV STEM+H (USDE #P031S150028) Projects, UT has designed, developed, and implemented highly successful tutoring academic support programs. While the TV STEM Engineering Project conducted a tutoring program mainly focused on courses in the engineering curricula with high failure rates, the STEM+H Project has expanded these services for all students enrolled in high-risk courses in STEM+H fields. Recognizing these challenges, it is imperative to provide ample student support opportunities and training for faculty members in STEM areas, whose expertise is often mainly technical and not education-related, as well. Therefore, two externally funded projects have focused on implementing initiatives utilizing peer-mentored academic support programs and comprehensive faculty training programs to increase students' academic success and retention.

Historical background

Universidad del Turabo (UT) is part of the Ana G. Méndez University System (AGMUS, as its English acronym), the largest private university system in Puerto Rico. Its vision statement, "*to become the first choice for all motivated students who wish to pursue an engineering education,"* (excerpt of the School of Engineering (SOE) vision statement) stems from the ideals of the founder of AGMUS, the late Ms. Ana G. Méndez. She initiated the AGMUS educational system 65 years ago as a means for Puerto Rican youth who, although capable and motivated, lacked the necessary skills required to continue university-level studies. In many cases, these students were, and still are, the first generation in their families to attend a university. Ms. Ana G. Méndez opened the doors of opportunity to this segment of the population. The institution serves a community student body composed of young and professional adult students in day and evening programs. The student population is mostly drawn from the surrounding communities with diverse economic and educational backgrounds.

The main campus in Gurabo, which serves a 100% Hispanic population, together with its additional instructional locations (Barceloneta, Cayey, Yabucoa, Isabela and Ponce), provides accessible education opportunities to 17,235 low income Hispanic students, according to AGMUS statistics for the fall semester of the 2015-2016 Academic year. The word "all" in the vision statement excerpt indicates that, while keeping the spirit of opportunity that inspired Ana G. Méndez, the engineering programs are not limited by it, nor other challenging STEM+H programs. These programs strive to attract highly skilled and motivated students that, once admitted, are put through the rigor of a demanding curricula regardless of their background (García, Morales & Rivera, 2014).

Summer faculty immersion program (SFIP)

Extensive literature has shown for many years that students prefer strategies that promote active learning over traditional lectures (Chickering and Gamson,1987; Bonwell and Eison, 1991; Prince, 2004). Students can be taught more effective problem-solving skills and strategies to improve their understanding of concepts by instructional practices that provide steps and prompts to guide them, use multiple ways to represent those concepts, and help them to make their own thinking visible. Faculty need- to shift their focus from purely course content and examine ways to increase student involvement, including proven teaching techniques and effective communication with their students. There is strong empirical evidence that the inclusion of active learning in the learning process is very important in two areas: (a) for the mastery of skills, such as critical thinking and problem solving; and (b) for contributing to the student's likelihood of persisting to program completion (Braxton, Jones, Hirschy, & Hartley, 2008; Prince, 2004). Active learning activities promote interaction among students in the classroom and beyond, as well as result in deeper conceptual understanding and long term retention of learning, which helps to increase student success and persistence in the STEM disciplines (Fisher, Dufault, Repice & Frey, 2013). Faculty development opportunities for learning, discussion, and collaboration help them rethink and revise the way to teach their respective courses, refine how they implement and evaluate active learning in the classroom, and increase student's motivation to remain in the course and be successful as well.

The Summer Faculty Immersion Program (SFIP) is a teacher training program with the primary objectives of developing faculty skills and improving teaching methodologies, with the overarching goals of increasing academic performance and retention. The SFIP program objective is to produce systemic and sustainable changes for creating a teaching setting that engages students with authentic, real-world problems within an inductive teaching/learning environment. This model presents a possible solution to a problem identified in the recent research literature: despite decades of efforts dedicated to the improvement of engineering education, and despite the many advances that have been well-researched and are readily available in the literature, the faculty are not readily adopting them because the time required to develop them substantially exceeds the normal course preparation (Morales and Prince, 2015). An additional concern for the application of active learning strategies is the fact that the professor needs to be creative enough to successfully implement these techniques and create the appropriate learning environment. Therefore, to provide its participants with all the necessary tools for applying its teachings, the SFIP provides its trainees with the time and funding for the instructional materials and laboratory equipment needed.

The SFIP began in Summer 2012, created and directed by Dr. Juan C. Morales, head of the Mechanical Engineering Department at the UT School of Engineering (SOE).. The SFIP focuses on faculty development during one (1) month in the summer, while they are free from their regular duties of the semester (Morales and Prince, 2014). Its goal was to effectively train the whole faculty of the SOE and the Physics Department. Morales and Prince (2012) provide a detailed description of the SFIP structure and inner workings. During Summer 2016, all Engineering and Physics regular faculty (30 overall) benefited from this intensive workshop. Simultaneously, the evolution of the SFIP was being implemented by the TV STEM+H Project. Recognizing the fact that schools aside from the School of Engineering don't have as many full time faculty, the TV STEM+H Project also focused on adjunct faculty, providing them similar opportunities for their professional development. The mix of faculty from diverse fields is considered a very important part of the project, given the multidisciplinary aspect which allowed participants to practice their newly acquired techniques with peers. Already, fifteen (15) faculty members (14 adjuncts and 1 full time) were successfully trained on active learning, teaching strategies, transformational leadership, instructional objectives, assessment techniques, educational technologies, retention strategies, rubrics, effective communication, and test construction in June 2016. Pre- and post-tests were utilized to assess the level of learning of these skills by the participants, and they demonstrated a significant increase in the faculty's learning, as shown in Figure 1.

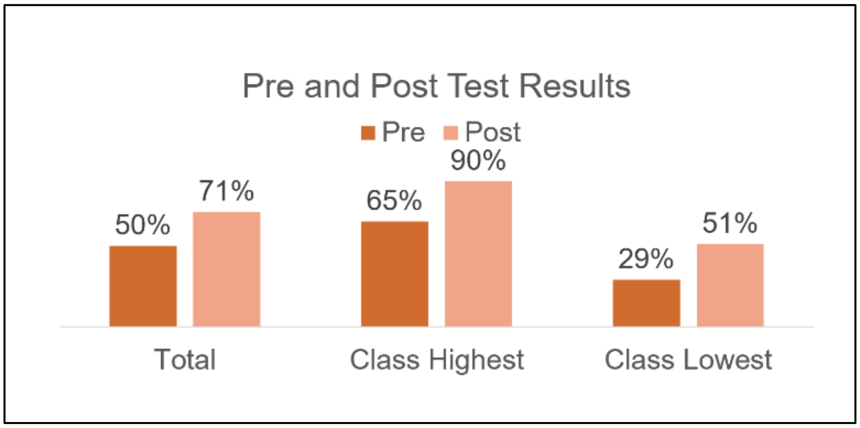

Figure 1: TV STEM+H SFIP Pre and Post Test Results

An additional, unforeseen benefit was that, thanks to the training received during the SFIP workshops, the TV STEM+H staff prepared shorter, one-day versions of the workshops for other adjunct faculty members on active learning and teaching strategies for the UT centers. Both centers provided impressive turnouts, bringing 33 out of 36 (92%) and 38 out of 42 (90%) of Cayey and Ponce adjunct faculty, respectively. This opportunity was really appreciated by the adjunct faculty, as there are not as many opportunities for professional development available that benefit directly their repertoire of teaching skills.

The TV STEM SFIP has been well received by the faculty. They report enjoying the experiences with innovative teaching methodologies and that students are more engaged in the classroom. Diffusion of the SFIP teachings is taking place in 60% of the lectures and faculty members are transforming, on their own time, additional courses during the SFIP summer (40% of the lectures). The biggest challenge identified by the faculty is time for implementing these innovations and still covering the syllabus content, which suggests that better time management is required in the classroom (Morales, J. C., Connor, K. A., Astatke, Y., Vergara, I., Ruales, M. C., & Prince, M., 2015). The Exit Survey that mechanical engineering students complete at the end of their last semester, which was one of the main catalysts for the SFIP creation, provides an excellent assessment tool for the SFIP impact on students. As discussed by Morales and Prince (2015), the "Liked Least" comment that surfaced with the the most frequency (16%-20%) was "too much theory without a practical context." After three successful implementations of the SFIP, the frequency of that comment was reduced to 5%. Moreover, in the "Liked Best" category of the Exit Survey, a student mentioned the use of Everyday Engineering Examples (a teaching strategy that focuses on explaining engineering concepts with ordinary, day-to-day examples that students can readily relate with), which was introduced as part of the SFIP strategies in the classroom. This also shows that students are, in fact, enjoying and being engaged by the new experiences in their transformed courses. More information about the active learning strategies promoted by the SFIP and some results on their effectiveness can be found in Morales and Prince (2013, 2014, and 2015).

An assessment tool to ascertain the effectiveness of the active learning immersion and its application in the classroom was designed for the new SFIP. The instrument has 40 items in a Likert scale covering the five (5) major pedagogical areas of the teaching-learning process, which are motivation, structure, methodology, monitoring and evaluation. During this academic year, visits will be conducted to different courses of the SFIP participating faculty to evaluate and provide them with feedback and support in areas of opportunity that present, if any. In addition, a focus group with students enrolled in the courses of the SFIP participating faculty will be conducted on November 2016. The purpose of this activity is to gain insight on student perception of the active learning strategies implemented by the professor and their learning experiences compared with those courses in which faculty members were not SFIP-trained. Official results for the TV STEM+H SFIP are yet to be obtained since it just started. Preliminary findings appear extremely promising and will be discussed in future publications.

Academic support programs

Learning assistance programs, such as tutoring services and academic support programs, provide student-centered instruction that developed skills and behaviors that improve learning outcomes (Brown, 2005). UT has successfully utilized this technique for a long time. In many colleges today, peer mentoring continues to be an integral part of academic support programs designed for the general student population. The advantages of peer mentoring programs are well documented in STEM+H- related careers, particularly in remedial courses (Bowen, Prior, Lloyd, Thomas, & Newman-Ford, 2007). From both their literature review and their own research, Henderson, Fadali & Johnson (2002), concluded that peer tutoring has a positive effect on student achievement and retention in engineering students, while generally showing a positive attitude towards academic support programs. Martínez (2014) established that peer mentors are also benefitted by developing deep learning of concepts on their own discipline, effective study skills, and by having to communicate clearly with their peers. Martínez further notes that they also benefit by acquiring leadership and other “soft skills” that are positive additions to their professional growth. Power & Dunphy (2010) describe the peer tutoring environment as a "safe and non-threatening interactive learning situation," which promotes student engagement.

There is an additional advantage obtained from this teaching strategy, which is the deeper learning of concepts obtained by the tutors. Beasley (1997) and Davis & Wilcock (2004) point out the benefits that peer-tutoring sessions, whether they are formal or informal, provide for tutors themselves, making it a valuable experience for the tutor's personal and professional development as well. When peer tutoring works, two students benefit simultaneously from the process. Therefore, student tutors can, in fact, learn from their teaching experiences (Roscoe & Chi, 2008). Atkinson, Renkl, & Merrill (2003) argue that the tutors' need to use examples to demonstrate important concepts and processes improves the self-learning process; additionally, research on learning from worked-out examples has shown that they gain a deeper understanding by dissecting examples into steps and associating them to fundamental principles. On the other hand, a successful peer mentoring program requires that tutors must be trained. The need of having trained tutors is evident, as they have significantly higher success with students because they tend to be more confident when they serve students, as they utilize the appropriate manners and the best strategies that they have learned (Kiat and Ong, 2015). Effective tutors guide students' actions and drive the tutees to perform at levels similar to themselves, thus eliciting success in their academic achievement.

This is why the academic support programs are the most important aspects of the Title V STEM and the Title V STEM+H Projects. . Although the Title V STEM project originally focused on six (6) mid-level courses with high failure rates (Physics I and II, Statics, Dynamics, Thermodynamics I, and Electrical Networks I, ranging from 33% to 68%), the project managed to expand the peer mentoring services with the same resources to other courses of the School of Engineering (SOE). This ambitious task was achieved by identifying and recruiting top students and breaking the mold on typical tutoring sessions. Even though these courses are still the priority, the offering of the peer mentoring sessions covered the majority of courses taught in the SOE, further contributing to retaining and graduating engineering students. At least one mentor was always available from 9:00 am to 9:00 pm from Monday to Thursday, and from 9:00 am to 5:00 pm on Fridays. Tutors were identified with name tags and promotional posters with their pictures were printed and distributed throughout the SOE for easy recognition. It is noteworthy to mention that a study area in the SOE was refurbished with four (4) stations for the peer-mentoring sessions to take place. Taking advantage of the available technological resources, an email account was created for students to contact the tutors online for quick questions or for scheduling mentoring sessions. Also, an online calendar was created for the mentors so they can schedule easily sessions for them or fellow mentors. Per semester, on average, nine (9) tutors were recruited, offering 290 peer-mentored 1-hour (minimum) sessions, which benefited over 100 SOE students in more than 30 different engineering, physics, and mathematics courses.

The need to provide STEM students alternatives to reach the entry-level mathematics requirements in those curriculums gave rise to the creation and implementation of the summer mathematics tutoring program (SMTP). The SMTP allowed enrolled students to advance during the summer previous to their first semester up to MATH 221 Calculus I. The program consisted of pairs of peer mentors working with groups of students on different math levels in one week sessions. Each weekly intensive session prepared the student for taking a placement exam for that particular course, which is part of the admission process for them, and, thus, free of charge. If successful, the student was encouraged to take the next tier of tutoring sessions until they no longer approve any more placement exams. Before implementing the SMTP, the average passing rate of mathematics placement exams by engineering students was 15% in 2011. By 2013, passing rates had improved to 42% and in 2014, the percentage of students that participated in the SMTP and approved one or more placement exams was an impressive 74%. An extensive explanation of the program can be found in García et. al., 2014.

Based on the Ferris State University student learning assistance (SLA) model, under the TV STEM+H project, an SLA program was developed and implemented to help increase the number of students passing in chemistry, biology, physics, mathematics, and other health sciences high-risk courses. This campus-wide peer mentoring program has also been successfully extended to the other five (5) UT instructional locations beyond the main Gurabo campus as well (Barceloneta, Ponce, Cayey, Isabela and Yabucoa). Many factors were incorporated in this program, such as anticipated student benefit, academic need, faculty commitment, and staff expertise. The goals and efforts of SLA program are tied to the UT mission, course purpose, and work environment. The targets are STEM+H high-risk courses and *not students*. Also, the SLA program provides a wide variety of services to strengthen UT STEM+H students' study skills to improve their performance in their courses, promote collaborative learning and group activities, time management; and develop integrative thinking skills, interdependence and self-authorship to become lifelong learners. Undergraduate upper-level students (juniors and seniors), in collaboration with professors, develop workshop material for the targeted courses. Tutors clarify lecture points and assist students in applying learning strategies and understanding the expectation of the professor.

Finding ways to access and engage students to participate in tutoring programs is an ongoing challenge. Based on the premise that our students are savvy in social media tools, but not in educational technologies, innovative technologies were incorporated to provide them with a way to be informed about the tutoring program services, as well as to schedule appointments using electronic devices such as laptops, smartphones, and tablets, among others. The SLA Program offers up to one hundred (100) hours of free tutoring per STEM+H course each semester. Sixty (60) SLA tutors (30 at UT main campus and six (6) for each UT additional location) were recruited and trained in the best current tutoring practices and on peer-mentoring strategies relevant to their discipline. Services are available Mondays through Thursdays, from 8:00 am to 10:00 pm, and Fridays, from 8:00 pm to 6:00 pm. A total of 7,568 academic support services for thirty-six (36) STEM+H high-risk courses were offered between UT main campus and its additional instructional locations during the period from January and July 2016, benefitting 927 students in these careers. Obtained data shows there is a significant difference in student success rates (SSR) between SLA participants and non-SLA participants. SLA participants had an average 12% increase in SSR, as shown in Figure 2 below. It is important to note that, due to unforeseen conditions, the SLA model was implemented late in the Yabucoa Center, which shows the least benefit from the program. The average SSR for SLA participants was 85% versus 73% of non-SLA participants.

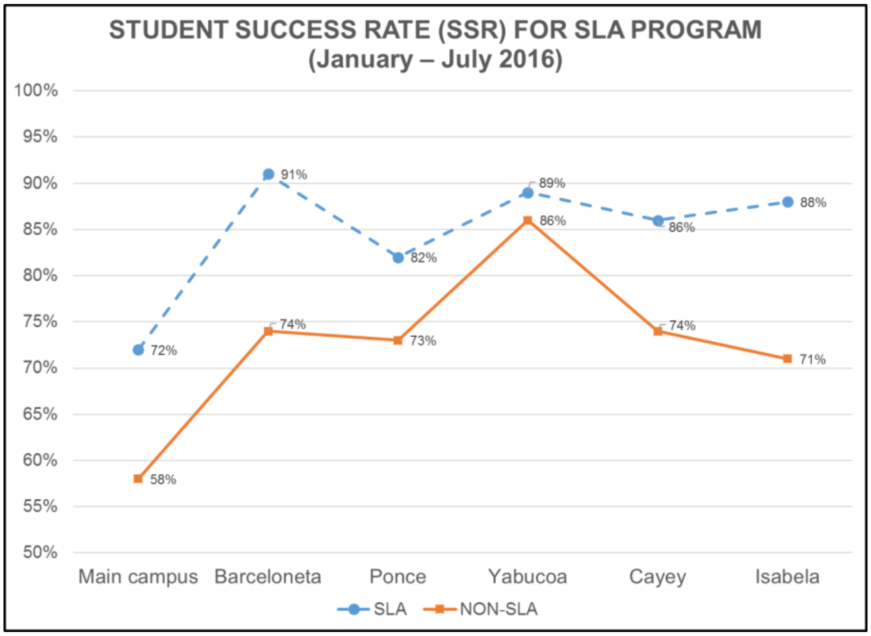

Figure 2: SSR for SLA and Non-SLA participants

Since the beginning of the 2016 fall semester, a technological tool through a web page was incorporated as a pilot test, to allow students to make appointments for the different services provided by the SLA program. A total of 2,152 appointments were made using this tool during the first three weeks of the semester (from August 23 to September 2, 2016), which exceeded the expectations when compared with only 65 appointments made during the same period last year (over 33 times more). This radical increase indicates that student engagement through thoughtful implementation and appropriate promotion of technological tools is possible. Additionally, five (5) online course modules have been created for Biology, Chemistry, and Mathematics to provide supplemental materials for all students. These modules were reviewed and approved by the respective professors and are readily available for students to further support their academic achievement.

An outcrop of the SLA Program has been the Mentoring-Challenge Program (MCP). The MCP provides free academic mentoring to challenge courses from MATH 120 Introduction to Algebra to MATH 151 Pre-Calculus I for students enrolled in a baccalaureate business, science or engineering program. The MCP allows the student to approve developmental math courses through the challenge modality without being enrolled in them, while taking officially other curriculum courses. The program provides 30 contact hours (minimum) of academic services with peer mentors during a five (5) week period, with the main goal of advancing students in the mathematical curricular sequence and bringing them up to speed with other peers who enrolled in the program at the prescribed math level. Since the MCP Program began implementation in Fall 2016, no results have been recorded yet. Nevertheless, assessment tools have been developed and are being employed.

Final remarks and recommendations

Successful implementation of initiatives, utilizing peer-mentored academic support programs and comprehensive faculty training programs to increase students' academic success and retention have proved to be powerful tools for helping HSI students achieve their academic goals in STEM+H careers. So far, the SFIP program has formally trained 45 faculty members between full time (31) and adjunct (14). Additional training workshops for the Cayey and Ponce centers were conducted, benefitting 71 adjunct faculty members (approximately 90% of faculty of the centers). Five (5) course guides have been created. They have been distributed amongst fellow faculty members teaching those courses, helping diffuse the innovative techniques and promote a change in teaching philosophies. By year 2020, it is expected that the SFIP will formally train a minimum of sixty (60) additional faculty members under the Project TV STEM+H, without considering the additional workshops that are planned to be delivered to the other UT centers. It is noteworthy to mention that, for the 2017 SFIP, the workshop will be opened for up to twenty (20) participants, which may broaden its effect beyond the expected 60.

Findings suggest that having an academic support program based on peer-mentoring strategies is a rewarding and enriching experience for all the participants involved, especially for STEM+H students. The development and implementation of a Structured Learning Assistance (SLA) program for STEM+H courses has had great acceptance among students of Universidad del Turabo and its additional locations. This is evidenced by the number of academic support services offered (over 8,000) and the number of students being benefited (over 900) under the two different projects. The inclusion of effective online tools for providing access to scheduling academic support services in a timely manner has also proved to be successful for engaging students. It is relevant to note that results related to student participation in the SLA program in academic achievement have only been evaluated for a short term. These students should be assessed throughout the years to evaluate long-term effects on academic success and retention as well. Future research should also explore the perception of students on active learning experiences for STEM+H courses. Further, the conversion rate of the appointments made by web and the actual services provided should be investigated. Finally, research on the impact of these programs on student success indicators should also be conducted.

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