



NSF Bridges to STEM Careers

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I have a "B.S. in Mathematics" from Rensselaer Polytechnic Institute, a "Master of Science in Engineering Management" from Northeastern University and a Ph.D. (ABD) in Computer Science from the University of Houston (Main Campus). In addition, I have completed graduate courses at San Jose State University in mathematics and graduate courses in business at the University of Houston (Clear Lake). My teaching experience spans over 40 years. This including teaching computer science and computer information technology at San Jacinto College for thirty seven years and as an adjunct at the University of Houston (Clear Lake), for over thirty years, teaching computer science. I served two years as a Lieutenant in the US Army Intelligence and Security Agency, conducted computer research on Project MAC at MIT and started my own computer software business

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Bridges to STEM Careers Project-Based Success

1. Introduction

The NSF Bridges to STEM Careers program is a five-year collaborative grant between University of Houston – Clear Lake (UHCL) and San Jacinto College (SJC) that aims to increase student success in STEM fields between the schools with focus on mathematics, physics, computer science, and computer engineering. The elements of the grant are Summer Orientations, Tech Fridays, STEM Challenge, Peer Mentoring and Scholarships. The university and community college work together to design and facilitate events, many of which are student-driven. The overall objective of the grant is to increase student success through a transferable model that uses both formal and informal elements of education. Specific objectives along with their statuses are listed in Table 1. The objective of providing a seamless transfer to partner universities for underrepresented students is coupled with industry mentoring to create a technology-enhanced community. Initiatives are supported by a cyber-center website for communication and event registration. Assessment is performed by an external evaluator to improve activities and gain feedback.

Many of the grant goals have been met. In addition, the grant has helped San Jacinto College to be recognized by the Aspen Institute as one of the top schools of its kind in the nation, awarding the Rising Star Award. Many of the projects of the grant are sponsored by industry partners and are highlighted in the text. One primary obstacle facing our students and others around the nation in degree attainment is the lack of engagement with peers and career opportunities [1], [2]. Our method of formal class projects and informal learning opportunities at all four campuses addresses this issue through team-building and project-based activities.

The main goals of the ongoing project are to increase the recruitment and retention of STEM majors from the high schools to the junior college, through a university, and out to industry. This is done through increased engagement with the industry professionals and using support networks of students.

Table 1: This is a breakdown of the grant objectives and their status during the final year of the grant.

Grant Objectives		
Type	Objective	Status
Shared SJC and UHCL	Yearly, enroll 60 SJC students and 40 UHCL students (100 total) who show academic potential and are either underrepresented in STEM, or are veterans, into the BSC program.	Met
Shared SJC and UHCL	Have 20 additional SJC students transfer to UHCL (or another university program), which presents an overall increase of 7% of students transferring from SJC to UHCL in STEM fields. The program will provide increased facilitation for all STEM transfer students, with special focus on computer science, computer information systems, computer engineering, physics and information technology.	Met
Shared SJC and UHCL	Strengthen ties between STEM programs at SJC and UHCL through joint student activities and additional specialized articulation agreements.	Met
SJC	Increase the number of students receiving STEM associate degrees yearly at SJC by 30, or 3%.	Met
UHCL	Increase the percentage of students from underrepresented groups pursuing and receiving STEM degrees at UHCL to at least 30% across all fields.	Met
UHCL	Increase the number of bachelor degrees awarded yearly in STEM at UHCL by at least 15%, or 20 degrees, over the current number. Through this cohort-based program, the aim is for an additional 80 associates and 80 baccalaureate degrees awarded over the grant period.	Met
Dissemination	Provide a model, transferable program.	In Progress
Dissemination	Provide a study of the effectiveness of student-led technology activities, facilitated by a student-run website and other social media outlets, in recruiting, retaining and graduating students (particularly from underrepresented groups such as females and Hispanics/Latinos) in STEM fields.	In Progress

2. Grant activities

The BSC co-principal investigator (CO-PI) team is comprised of faculty from all campuses and meets each month to coordinate activities. The intentional connections from the activities are intended to make a student more likely to attend the university and complete a bachelor's degree.

2.1 Gateway class peer mentoring

Each campus has peer mentors for gateway classes, particularly introductory computer science and mathematics courses. These mentors prepare reviews and tutoring for students in introductory courses and provide them with information to move further into the sequence. These mentors are selected from a pool of outstanding students and are paid to be both in the classroom and outside of the classroom to provide a seamless transition for students to study.

BSC peer mentoring in college algebra and precalculus have shown to increase retention rates by over 15% and success rates by over 10% when compared to equivalent non-mentored sections of the same course. In addition, the student mentors have provided class notes and exam reviews for courses.

2.2 Project-based peer mentoring

Honors courses at San Jacinto College provide opportunities to be involved in projects that are industry-driven and are connected to senior design projects at the partnered universities. To this extent, there are faculty mentors, industry mentors, and peer mentors. The peer mentors for these courses are selected from a pool of outstanding mathematics, engineering, and computer science majors who have excelled in previous projects and are comfortable with documentation processes. The projects follow a successful model of project-based construction for industry partners, using the AI-Tech Labs in place of the UCF EXCEL Program [3] for gathering and distributing projects.

Groups of students for honors projects have a choice of using pre-determined problems provided by faculty who integrate with industry or to decide their own project. Projects can be completed by individual students or in teams and can be completed for a single course or multiple courses. For each course that each student receives honors credit, they are required to explain how the project will enhance the learning outcomes on a proposal.

2.3 Tech Fridays

Tech Fridays are held three times per semester and are designed and facilitated by peer mentors and faculty. In addition, industry partners and speakers are invited. Activities are scheduled to be three hours long and consist of lesson plans and a guided lesson. The lesson plans are printed and provided to help students with formation in case they get lost or stuck during the lesson. Mentors walk the room and help the students individually to make sure everyone can persevere while challenges are issued to advanced students to keep them working. The Tech Fridays are archived on the BSC website for anyone who missed and would like to go through the lesson on their own, complete with lecture and video.

Table 2: Tech Fridays and a summary of the activity.

Topic	Activity
Robotics	Students worked with both Arduino boards and sensors, as well as Arbotix robotics kits.
Computer Forensic Investigation	Students worked on solving a simulated case using forensic software tools [4] . A Houston police officer talked with students about his experience as a computer forensics specialist.
Raspberry Pi	Students learned programming concepts using Raspberry Pis.
Web Development	Students were taught how to develop web pages. An experienced professional was invited to give background and a lecture on careers in web development.
Charlieplexing	Students wired LEDs and wrote programs to generate light sequencing.
Game Programming	Students developed a computer game.
Video and Sound Editing	Students learned how to edit sound, image, and video using free software.
Sound to Light	Students wired kits to convert sound to light.
NASA Swarmathon Intro	Students programmed a turtlebot in ROS, and the NASA Swarmathon was presented.
3D Printing	Students learned how to create and print 3D models on campus and at the local public library.
Soldering	Students learned how to solder and get soldering assistance at the local public library.

The students have about a week to register through the website and registration is typically limited to 40-50 students. BSC members who have signed up on the website get first notice, then those in proper majors, then finally the general student population. All Tech Fridays during the 2016-2017 school year were registered to capacity.

2.4 STEM Challenge

Spring 2017 was the third annual STEM challenge. 29 teams made up of 112 students participated in the competition at two levels: beginner and advanced. Winners and participants won prizes including scholarships, internships, quadcopters and various other gifts, as shown in Figure 1. The internships were provided by AtLink Communications Inc. and Tietronix.

STEM Challenge 2017 was sponsored by Flow-Cal Inc., Esyntaxis and AtLink Communications Inc. Breakfast was generously donated by Panera Bread. Lunch was provided at a concession rate by Freebirds Inc. Additional support was provided by various other companies and restaurants in the community. Faculty members from community colleges, high schools and UHCL participated actively and served as judges, mentors and in various other capacities. Industry representatives from Flow-Cal, AtLink and SAIC also served as judges.



Figure 1: A student receives an SSD as a prize in the 2017 STEM Challenge.

The challenge was open to all high school and undergraduate students. Students from many high schools, community colleges and universities were represented at the event. It consisted of two levels of competition, with all teams showcasing their capabilities in several areas ranging from creative abilities, engineering design abilities, math abilities to software design abilities. A total of 29 teams (19 beginner teams and 10 advanced teams) registered for the event. Each team consisted of a maximum of 4 members.

All challenges were taken from and inspired by STEM subjects and were designed in a way that allowed anyone to participate and succeed. The goals of the STEM Challenge were set to encourage students to pursue STEM fields, to recognize that STEM fields can be fun and to take away the fear of failure in a STEM field.

Each member of the overall winning team in the advanced category was awarded \$500 scholarships to UHCL. All members of this team also received summer internship positions at AtLink Inc or Tietronix. Each member of the overall winning team of the beginner category was awarded \$500 scholarships to UHCL along with Amazon Echo Dots. Each member of the winning team for each of the three stations received \$300 scholarship to UHCL and a quadcopter. Several departments at UHCL and area restaurants and vendors contributed door prizes, such as 1TB and 2TB solid state external hard drives, Raspberry Pis, gift cards and UHCL memorabilia. Participants also each received a t-shirt and a water bottle. Both breakfast and lunch was served.

2.5 BSC Orientation

Five years of successful orientations have been executed. The orientation brings together students from various stages of their STEM education. The first two years had community college students from individual campuses the first day and then all together across the district

on the second day. These have been combined into a single day at the community college to accommodate more student work schedules. On the first day, community college students convene at one of the SJC campuses, and new UHCL STEM majors convene at UHCL. A motivational speaker presents at the SJC campus. At UHCL students participate in activities to get familiar with the UHCL campus. They also engage with a faculty panel and a student mentor panel, and are assigned to specific BSC mentors. On the second day, all student participants convene at UHCL for team-building activities. They engage with a panel of academic and transfer advisers, financial aid officers, and student services representatives.

Each day is a morning event that ends with lunch at noon. All students receive prizes and giveaways. 78 students attended the 2015 orientation. Of the students who participated in the post-survey, 100% responded positively to the following questions:

- The BSC orientation enabled me to network with my fellow students
- During the BSC orientation, I learned more about campus resources available for students
- During the BSC orientation, I learned more about succeeding in college from current students
- During the BSC orientation, I have learned more about succeeding in college from professors, advisors, and administrators

Initially, orientations were planned to be three longer days but was instead designed for two half days because of the student's work schedules and other obligations. The shorter orientations are more successful in having students attend and get the critical information about scholarships and opportunities. Each student receives giveaway items, including a pen and a shirt and then other items such as a Raspberry Pi 3, backpack with school supplies, or other BSC giveaways. Food has been provided by Bibi's House of Kabob, a family-owned local restaurant and strong supporter of the colleges.

3. Evaluations

3.1 Internal and external advisory boards

The Internal Advisory Board (IAB) for the BSC project consists of UHCL and community college administrators and senior faculty members. The External Advisory Board (EAB) members consist of members of local STEM industries. We have been meeting with the IAB semi-annually, and with the EAB annually to report progress and to receive feedback and advice. This gives the BSC Executive team the opportunity to learn of ways to improve the efficiency of our project activities, such as continuing with the theme of the annual STEM challenge, incorporating more hands-on activities, and involving outside experts in project activities.

3.2 External evaluator

The external evaluator for the BSC project evaluates the effectiveness of activities. With a mix of qualitative and quantitative data gathered through open-ended surveys, face-to-face interviews, and observations of the events, data is collected and analyzed. For major events, pre and post survey data is collected.

4. Analysis

Grant expectations focused on student success through formal and informal learning opportunities. Sustainability of the grant shall be accomplished through college adaptation to successful elements, continuing grants, and community partnerships. These sustained results are intended to continue enhancing student success in academic and technical programs where there is industry need.

Graduation numbers by program and overall in the focused upon STEM fields are shown in Figure 2, where the year before the grant and the years of the grant are shown. Note that the engineering program was only started in 2015 and so the data is zero before then, which is the grey line in the plot. The introduction and early success of the engineering program highlights the success of the mathematics program and our ability to transfer these credits seamlessly into the UH System through the partnership. The degrees awarded have increased by more than the 30 expected because of the grant, exceeding the total number by greater than 60%. This increase is coupled with the redesign of the academic programs for total alignment within the state and a mock ABET accreditation in conjunction with the University of Houston System to ensure quality standards within the programs. Similarly, UHCL has increased by more than the projected 80 students, showing numbers of an increase of 322 students by Spring 2016.

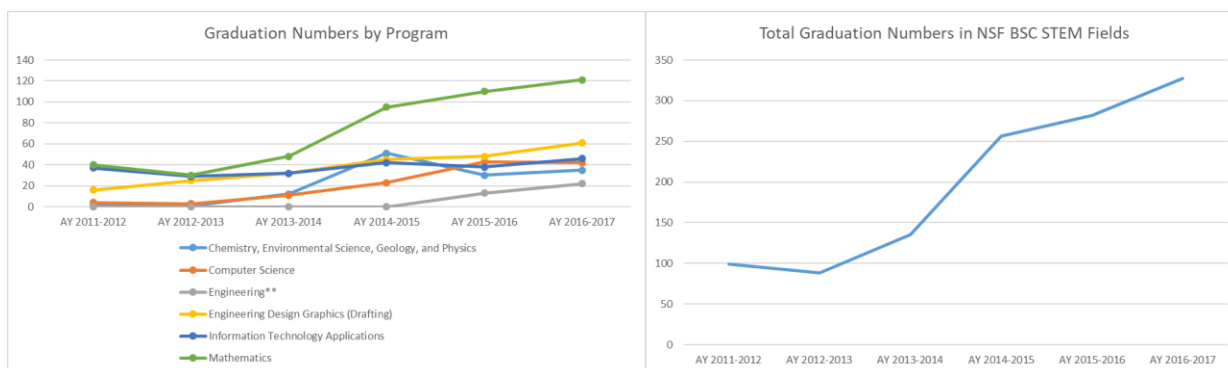


Figure 2: Graduation data before and during the NSF BSC grant at San Jacinto College.

Recent collaborative projects between San Jacinto College and the University of Houston System have driven the increase in the programs as the recruiting and outreach to the region has increased. The San Jacinto College AI-Tech Lab Assistants and BSC Peer Mentors account for outreach to more than 10,000 K12 students in the service region in the 2016-2017 school year, for which one of the outreach videos is linked in Appendix A. Knowledge dissemination by students accounts for student publications in the research areas, mainly in robotics and gaming. Peer mentoring classes in honors courses at San Jacinto College and senior design courses at UHCL, UH, UT-Tyler Houston, and Lamar have allowed students to interact with the programs in which they plan to transfer and contribute to meaningful research. Figure 3 shows some resulting graphics from the research.

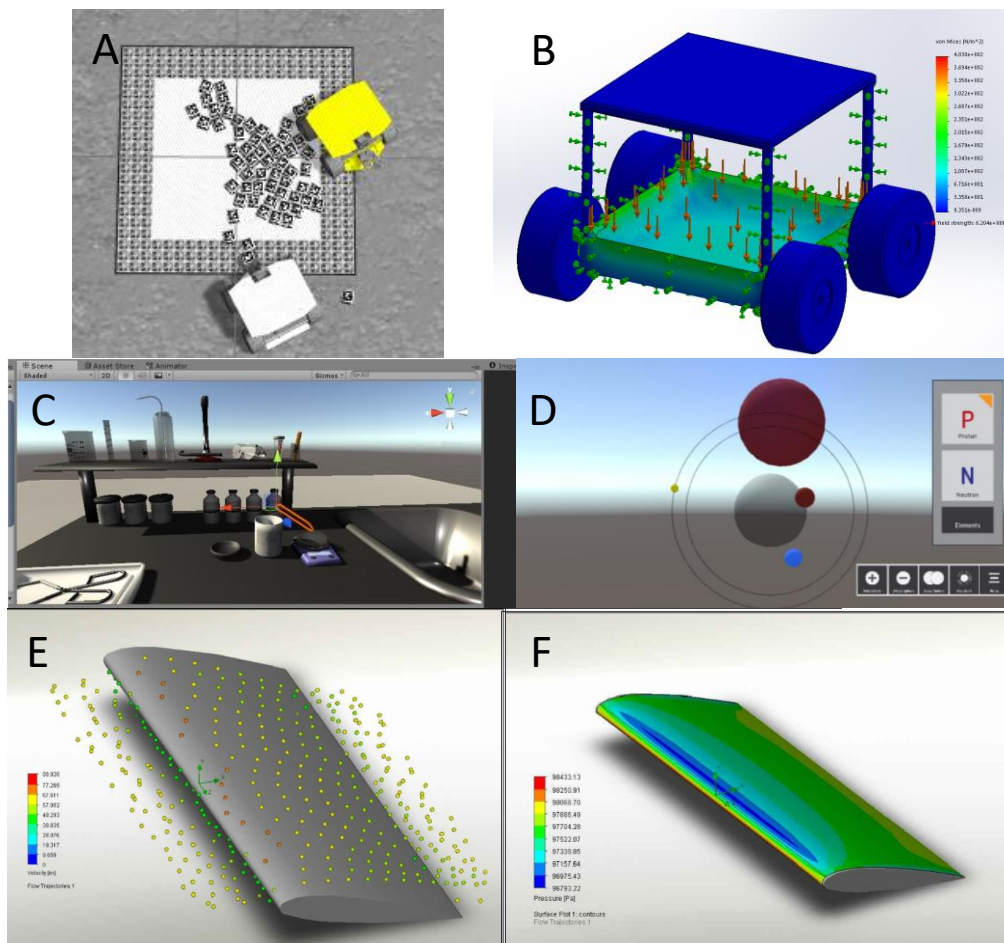


Figure 3: A: Capture from NASA Swarmathon Gazebo simulation. B: FEA of NASA Swarmbot in Solidworks 2016. C: Lab simulation in augmented reality. D: Molecule builder in augmented reality. E: Particle simulation on modified NACA Airfoil series. F: Fluid simulation on modified NACA Airfoil series.

Peer mentoring in math, engineering, physics, and chemistry classes coupled with projects allows students to have support while contributing towards regional and national competitions. The NASA Swarmathon is a national competition where the students maintain physical robots and create a swarm code to collect cubes with specialized tags on them. Interestingly, several students from the competition have gained internships at Boeing and Leidos in both systems as well as cyber-security. An augmented reality application to teach chemistry, partnered with San Jacinto College and Sheer Industries, has allowed students at Samford International American School in Singapore to learn from students in the Houston region. Additionally, students in this research area have published and presented in 3D printing, 3D scanning [5], and augmented reality. The Space Alliance Technology Outreach Program (SATOP) branch of the Bay Area Houston Economic Partnership (BAHEP) has allowed students to complete work for small industry partners, including a NACA Airfoil wing design patent from James Lawrence which has created continuing funding for the AI-Tech Labs. These projects and others contribute to the

success of the students while supporting the projects for the next students, allowing sustainability of project-based courses.

The peer mentoring in gateway classes has been successful, with gateway algebra classes with a peer mentor to have a success rate of more than 10% higher than the non-mentored courses (N~12 courses). This has allowed San Jacinto College to allow more tutors into the classroom and to find more tutoring funds for the peer mentors. Additionally, the college has allocated AI-Tech Lab assistants to assist with the peer mentoring and project mentoring, showing sustainability of the peer mentoring program.

The Tech Fridays will be continued under new grants and awards, as will the BSC Orientation. The STEM Challenge will be sustained through partnerships with the aerospace industry in the region and continued grants. These elements of the grant have been successful and will be sustained through internal and external funding.

5. Conclusions and lessons learned

San Jacinto College has been named as one of the top five schools in the nation by the Aspen Institute and has received the Rising Star Award in part from this research. The combined team of UHCL and SJC has received 6th place and 4th place respectively in the first two years of the physical NASA Swarmathon competition. The NACA Airfoil design won an award for top project at the UHCL Research and Creative Arts Conference in Spring 2017. Industry partnerships and peer mentoring drive the program's growth.

It can be observed from the BSC Cyber Center registration system that student events consistently fill up and that students will attend events where hands-on learning opportunities exist. The engagement of industry mentors with the students has increased the number of internships with the region. The interaction of students in competitions motivates the students to take on more challenging projects in STEM areas than they would engage in with traditional courses. Finally, having students carry out lessons and activities builds self-confidence and speaking skills.

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Acknowledgements

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Appendix A

Outreach Video for NASA Swarmathon: <https://youtu.be/IWCjBKXCfkM>