

TESTED STRATEGIES FOR RECRUITING AND RETENTION OF STEM MAJORS

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ABSTRACT

There is a shortage of STEM (Science, Technology, Engineering and Mathematics) educated workforce in the US, especially among minority and underrepresented groups. Recruiting and retaining STEM majors has been a major problem for universities and community colleges for many years. The Computer Science department of University of Houston-Clear Lake (UHCL) has been collaborating with three campuses of San Jacinto College (SJC) on recruiting and retention strategies. Our activities started taking off after we received a joint state grant to support our recruiting and retention activities. The grant allowed us to experiment with several pilot projects such as peer-mentoring and programming challenge. We then expanded our pilot project to include additional STEM fields and additional recruiting and retention strategies. The additional strategies included monthly Tech Fridays, annual Extended Orientation and annual STEM Challenge. We submitted a proposal to the US National Science Foundation (NSF) and received a 5-year joint grant from the STEP program of NSF with the start date of September 2013. Our NSF grant activities have been very successful. In 2016, we expanded our activities again by adding additional elements such as undergraduate research, internships, and creation of a new computer science teacher certification program. We submitted a proposal to the HSI-STEM program of the US Department of Education (DOE) with a focus on recruiting and retaining students from Hispanic or low-income families. We received a 5-year grant from DOE with a start date of October 2016. In this paper, we share our strategies and experience with conference participants, hoping that our experience will help others who are considering similar strategies for recruiting and retention of STEM majors.

KEYWORDS

STEM, Recruiting, Retention, Peer-Mentoring, Hands-on Activities

1. INTRODUCTION

In the United States (US), the number of occupations in STEM (Science, Technology, Engineering and Mathematics) fields has been growing rapidly in the past 10 years and the projection is that this growth rate will continue in the future [Noonan 2017]. The US lacks enough educated workforce to fill existing open STEM positions [Laros 2016]. Recruiting and retaining STEM majors has been a major problem for universities and community colleges in the US for many years. Until fall of 2014, our university, the university of Houston-Clear Lake (UHCL), was an upper-level institution. We offered only junior-, senior- and graduate-level courses. We did not offer freshman- and sophomore-level courses. Our undergraduate students mainly came from a handful of surrounding community colleges. In order to increase our undergraduate enrollment in STEM fields we had to help our main feeder colleges to fill their STEM classes. Ten years ago, we started collaborating with three campuses of the San Jacinto College (SJC) on recruiting and retention activities. At the time, over 50% of the UHCL undergraduate students came from SJC campuses. Our collaborative activities started taking off after we received our first joint grant from the Texas Workforce Commission. The title of this state-supported grant was “Computer Science Scholars: Recruiting, Retention, and Mentoring” [Abeysekera 2008, Davari 2007, Davari 2009]. The grant allowed us to experiment with several pilot projects. The results of our pilot projects were promising. We then started working on a new proposal to get a longer-term grant to be able to expand on our pilot projects and to include additional STEM fields. We submitted the proposal to the US National Science Foundation (NSF) for funding. On our third try, we received a 5-year joint grant from the STEP program of NSF with the start date of September 2013. The title of this grant is “Bridges to STEM Careers (BSC)”. Our NSF grant activities

have progressed very well [Abeysekera 2017, Perkins-Hall, 2017, Rosales, 2016]. In 2016, we expanded our activities again and prepared a new proposal for submission to the HSI-STEM program of the US Department of Education (DOE) with a focus on students from Hispanic and low-income families. We received a 5-year grant from DOE with a start date of October 2016. The title of this grant is “Pathways to STEM Careers: A University-Community College-Industry Collaboration.” In the following sections, we will expand on our major project activities in each of the three funded projects in chronological order.

2. DETAILS OF THE THREE FUNDED PROJECTS’ ACTIVITIES

2.1 Computer Science Scholars: Recruiting, Retention, and Mentoring

In 2006, we had a scholarship endowment grant for Computer Science (CS) majors from the state of Texas and a NSF Course Curriculum and Laboratory Improvement (CCLI) scholarship grant. These grants were producing a large number of scholarships each year. However, we could not find enough qualified candidates for these scholarships among the student population of local community colleges. We were also witnessing large drop rates on our campus in classes that transfer students took. We therefore decided to combine our recruitment and retention efforts with our SJC colleagues, in order to increase the number of CS majors and to improve the quality of the CS programs at all our campuses. We submitted a joint grant proposal to Texas Workforce Commission and received a two-phase grant with a total amount of \$300,000. Our proposed strategies included joint recruiting and retention strategies through peer mentoring. For recruiting, we prepared recruiting materials that highlighted the importance of majoring in CS and the benefits of joining SJC and then transferring to UHCL. We reached out to high school counselors and teachers, and arranged class visits. For retention, we created peer-mentoring centers in both institutions supported by eight undergraduate and one graduate CS major students. These qualified students mentored their peers in all programming-intensive courses that the incoming students took in their first year at each campus.

Student mentors received salaries paid by the grant that supplemented their scholarships. Even more rewarding was the reinforcement of the student’s knowledge in computer science courses through their mentoring activities. Student mentors also participated in the preparation of the recruiting material for on-campus and off-campus events. In the second year of this grant, with the help of student mentors, we planned and executed a successful programming challenge. Seven of the winners of the challenge joined our CS program. After the success of these pilot projects, we decided to prepare proposals to receive longer-term federal grants to allow us to continue our efforts, to expand on our strategies, and to include more STEM majors.

2.2 Bridges to STEM Careers (BSC)

After two unsuccessful tries with NSF programs, we received a 5-year STEM grant from the NSF STEP program for our expanded project. The total amount of this grant was approximately \$1.5 million. The main goal of this project was to increase the number of students ultimately graduating with STEM degrees. As such, our goals included an increase in the number of students graduating in STEM fields from each of the three campuses of SJC (a two-year college), facilitate and increase transfer of STEM majors from SJC to UHCL, and an increase in the number of students graduating in STEM fields from UHCL. We had proposed specific numerical goals for each of these sub-goals. We also intended to increase student engagement and persistence through the development of face-to-face and technology-enhanced learning communities, and collaborate with local industry professionals. The STEM fields we focused on included: Computer Science, Computer Information Systems, Information Technology, Computer Engineering, Mathematics, and Physics. Our supporting initiatives included an extended orientation during summer before the start of fall semester, peer-mentoring and tutoring sessions, development of a cyber-center to archive and disseminate resources, monthly Tech Fridays, annual STEM challenge with participation and sponsorship from local industry, and modest financial aid supporting students in STEM majors. Peer-mentoring and hands-on experiences with technology have shown to encourage students to choose and succeed in STEM fields [Jolly 2004, Zhao 2006].

Assessment by the external evaluator of our project has shown that students who have participated in these activities have gained confidence to continue in their STEM education. Participating students identified with other students with whom they can relate. We intend to provide a sustainable model that increases retention rates and provides opportunities for students to succeed in STEM fields.

All our project elements are based on best practices reported in the literature [ASE report 2012] and successful pilot studies [Abeysekera 2008, Davari 2007, Davari, 2008]. Student participants of the project are given opportunities to get directly involved in the design and the development of the project's cyber-center. Students are provided opportunities to practice teamwork, obtain internships, and have exposure to emerging technologies such as robotics, mobile application development, computer forensics, cyber-security, computer game programming, web design, video editing, etc.

The BSC Executive team, comprised of the Primary Investigator (PI) and co-PIs from all campuses, meets each month to plan and coordinate project activities. A main goal for student activities is to make students from other campuses feel welcomed, particularly those from community colleges, so that they might be more inclined to attend UHCL and complete their bachelor's degrees. The BAS project activities are given below.

2.2.1 BSC Club

A BSC club is active at all four campuses. Club members are encouraged to participate in activities and propose new activity topics at any of the campuses. Students use the clubs as an opportunity to network with other students and faculty.

2.2.2 Peer-Mentors

Each campus has a team of students who have various responsibilities, including tutoring; planning and executing BSC club activities; planning and executing monthly Tech Fridays; and preparing and administering the annual STEM challenge. Student mentors at all campuses attend targeted classes and serve as in-class mentors [Perkins-Hall 2017]. Mentors also hold regular office hours and act as tutors. They hold weekly recitation sessions on key topics in computing, engineering and mathematics. There were 13 different peer mentors throughout the year last year at UHCL.

2.2.3 Tech Fridays

Tech Fridays are designed by mentors and faculty to create learning opportunities. Industry and academic speakers are invited to provide relevance. Tech Fridays are held for three hours and consist of hands-on activities, worksheets and interaction with topic experts.

Tech Friday topics to date have included:

- Robotics: students work with Arduino boards and sensors.
- Computer Forensic Investigation: students worked on solving a simulated case using forensic software tools. A Houston police officer talked with students about his experience as computer forensics specialist and the opportunities in the field.
- Web Development: students are taught how to develop web pages.
- Video Editing: students learn how to edit sound, image, and video using free software.
- Arduino and Charlieplexing: students wire LEDs and write programs to generate light sequencing.
- Computer Game Programming: students develop computer games using free software.
- Sound-to-Light: students wire kits to convert sound to light.
- 3D Printing: arrangements are made with a local library to utilize their 3D printer for training and practice.
- Soldering: this also takes place at the local library. We provide the soldering kits.
- Python Warrior: this Tech Friday introduces Python Warrior to create a simple graphical game in which a player moves through levels avoiding enemies, gaining health, and attacking enemies.
- Swarmathon: the Robotic Operating Systems (ROS) is presented and entry-level applications on robotics are developed.

The events are usually at capacity with 35 to 50 students attending each event.

2.2.4 STEM Challenge

Each spring semester teams of students are invited to UHCL for a STEM challenge. The challenge requires teams to participate in three stations and complete several tasks of increased difficulty in succession. We categorize teams into beginner level or advanced level. The events are timed and checked for completion.

Challenges are open to high school and undergraduate students. Participants come from local high schools, home-schools, community colleges, universities, and sometimes middle schools. The first year was a robotics challenge and the three stations consisted of:

- Controlling Arduino and lights to produce Morse codes
- Reading sensor data such as temperature and water
- Moving a robotic tank through an obstacle course.

In subsequent years the challenges were renamed STEM Challenge with three stations that consisted of:

- Game of Clues to challenge math knowledge
- Creative Inventors to showcase imaginative skills
- Robot Adventure to test problem-solving and programming skills

Winning teams are offered scholarships to UHCL, summer internships with local industry, and other prizes. Raffle prizes are given to every participant.

Local industries and businesses sponsor the event and provide prizes. Industry partners and faculty serve as judges and technical program supervisors.

The events have always been at capacity. The robotics challenge hosted 15 teams and the latest STEM challenge hosted 29 teams made up of 111 students participating in the competition at the beginner and advanced levels. For more details about STEM Challenge, please refer to a companion paper titled “Challenges for a New Generation of STEM Students” to be presented in this conference.

2.2.5 Extended Orientation

We prepare and hold a 2-day extended orientation in August of each year. The orientation brings together students from various stages of their STEM education. On the first day, SJC students convene at one of the SJC campuses and new UHCL STEM majors convene at UHCL. At SJC, students are introduced to the campus, to student leaders and to faculty. A motivational speaker also presents at SJC. At UHCL, students participate in activities to get familiar with the campus. They also engage with a faculty panel and a student mentor panel, and are assigned to specific BSC mentors to guide them throughout the academic year. On the second day, student participants from all 4 campuses convene at UHCL for Team Building Activities. They engage with a panel of academic and transfer advisers, financial aid officers, and student services representatives.

In the most recent orientation, each day was an afternoon event that commenced with lunch at noon. 56 students attended the 2016 orientation. Each student received a BSC binder, a pen and a BSC t-shirt.

2.2.6 Cyber Center Website

The current functionalities that the Cyber Center hosts include: information about the BSC project, a news and comments system, site membership, events’ schedule and registration, photo and video archives from past STEM events, and other resources. UHCL hired a research assistant, paid by the grant, with the primary responsibility for developing and maintaining the Cyber Center. The planned additional functionalities include increased interactivity, more useful resources, and social media integration.

2.2.7 Internal/External Advisory Board Meetings

The Internal Advisory Board (IAB) for the BSC project consists of UHCL and SJC 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. In spring semesters, we combine IAB meeting and EAB meeting. In this meeting, we report to the board highlights of our major grant activities in the preceding year. This venue has given 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.

2.2.8 External Evaluator

The BSC project has an external evaluator who evaluates the effectiveness of major project activities. The evaluator collects a mix of qualitative and quantitative data. The qualitative data is collected via face-to-face interviews with students, open-ended survey questions, and observations during the events. The quantitative data is collected via pre- and post- surveys that measure students' preparedness, self-perceived aptitude, and attitudes/interest pertaining to STEM. Pre- and post-surveys are generated via Survey Monkey. A link to the survey is provided to each student and students access the link using cell phones or laptops. Students may also opt to take a hard copy of the survey. The evaluator stays in compliance with all UHCL IRB restrictions. Survey data is analyzed using SPSS. The results are provided to the BSC Executive team for possible actions.

2.2.9 Significant Results

Last year 228 unique students (50 female and 169 male) participated in one or more BSC project events such as Tech Fridays, STEM Challenge, and Extended Orientation. These are students who registered and participated in these events. It does not include the number of students who were mentored in classes, or those who were mentored in the mentoring centers or those who participated in recitation sessions. At UHCL, the total number of students in CS1 and CS2 classes in fall 16 and spring 17 semesters was 133. Many of these students received one-on-one mentoring in class and in the mentoring center. Students who visited the mentoring center and participated in recitation sessions also came from other classes in Computer Science, Computer Engineering, and Mathematics.

The enrollment data in the six STEM programs that are the main focus of the BSC project are provided in Table 1 below for spring 2013, which was the semester before the BSC project started, and for the spring 2017:

Table 1. Total Enrollment Data

Program	Enrollment in Spring 13	Enrollment in Spring 17
Computer Engineering	37	146
Computer Information Systems	58	98
Computer Science	51	185
Information Technology	51	74
Mathematical Sciences	51	127
Physics	15	36
Total	283	666

We should note that starting from fall 2014, UHCL switched from an upper-level institution to a 4-year institution. Therefore, in addition to the students who transferred from area community colleges, we have also been recruiting freshmen from area high schools starting from fall 2014. In Table 2, we show the change in the number of students who have transferred from the three campuses of SJC. The data shows that the total number of transfers from SJC campuses in the focused STEM programs increased from 153 in spring 2013 to 281 in spring 2017, an increase of 128 students (over 83%).

Table 2. Transfer Enrollment

Program	Transfers in Spring 13	Transfers in Spring 17
Computer Engineering	21	54
Computer Information Systems	36	42
Computer Science	33	73
Information Technology	23	46
Mathematical Sciences	30	51
Physics	10	15
Total Transfer	153	281

In addition, we have established strong relationships and benefitted from the involvement of our community/industrial partners. Representatives of these organizations have continued to give valuable input, help with the STEM Challenge, and attend our External Advisory Board meetings. This grant has allowed us

to enhance relationships with colleagues from community colleges and high schools, and strengthen relationships among students from all campuses.

We have witnessed significant professional growth from our student mentors. They develop ideas for Tech Fridays and present them. This year, three peer-mentors after graduating with their bachelor degree were accepted into doctoral programs at other universities. Other peer-mentors who have graduated have found lucrative jobs in local industry. Mentors have come from a diverse group, including Whites Americans, African Americans, Hispanic, Asian and women.

Students have indicated that their participation in BSC activities has made their transition to our university easier. Students become familiar with UHCL before they enroll here. Transfer students know UHCL students and faculty. They have the opportunity to get their questions answered by peer mentors and faculty, and benefit from early advising.

2.3 Pathways to STEM Careers: A University-Community College-Industry Partnership (PSC)

In fall of 2015, one year after UHCL started offering freshman and sophomore classes, we had a Friday Morning Breakfast meeting with teachers and counselors from area high schools and community colleges. Our goal in this meeting was to find out if their students could easily transition to our STEM programs. Several new ideas came out of this morning conversations, which we were not addressing in our existing STEM project activities. Afterward, jointly with our colleagues from the UHCL College of Education, we prepared a grant proposal to address the main issues that were raised in our meeting with folks from high schools and community colleges. Many of these high schools and colleges have the Hispanic Serving Institutions (HSI) designation. We submitted the proposal to the HSI-STEM program of DOE. We received a 5-year grant from DOE with a total amount of over \$3.77 million and a start date of October 1, 2016. Unfortunately, our community college partners with whom we have been collaborating could not join us in this proposal because they had lost their HSI designations.

2.3.1 Major Goals of PSC Project

- (a) Increase retention rate and the number of graduates in STEM fields among Hispanic and low-income students, by means of peer-mentoring, tutoring, and counseling;
- (b) Develop model transfer and articulation agreements in STEM fields with area HSI colleges;
- (c) Develop Computer Science 8-12 Teacher Certification Degree Program;
- (d) Provide culturally responsive professional development opportunities for faculty of UHCL, faculty in area HSI colleges, and area STEM teachers;
- (e) Provide opportunities for Hispanic/low income students to conduct paid scientific research with UHCL faculty;
- (f) Provide paid internship opportunities with local industry for Hispanic/low income students.

We have started the preliminary work on this project. The grant supports a full-time program director for 5 years. We also have the budget for 10 student peer-mentors' positions, 8 research assistants' positions for conducting research under the supervision of our faculty, and 8 paid internship positions to place recipients in positions at local industry and high schools. We conducted the search and hired a well-qualified program director. With the help of the program director, we are identifying qualifying cohort students, interns, research assistants, and peer-mentors. An applicant to any of these positions must either be Hispanic or be qualify as a low-income student.

3. CONCLUSION

Collaboration with the participating colleges has strengthened relationships between students, faculty and administration within all campuses. It has established a sense of community among students, faculty and industry partners. Students will make time to attend and participate if there is an opportunity to learn and experiment with STEM topics. The hands-on STEM activities will get student participants excited about pursuing careers in STEM. Tech Fridays also provide students an opportunity to build relationships with

other students interested in STEM careers, and gives them a chance to meet faculty and students from other campuses. STEM Challenge makes our students want to learn more about computer hardware, robotics and programming. When asked what was most liked about Tech Fridays, the responses included “The hands on working”; “That I got deep into how the computers actually work to access information. I learned tons of things I never knew about. I am definitely coming back next time.”; “This was an enjoyable experience. The infusion of mathematics was nice. Students need to know number theory!”; “I liked the relaxed, fun atmosphere.”

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