

Bridges to STEM Careers: A Student Mentor Perspective

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Jose Daniel was born in Jalisco, Mexico. Since his childhood, he has had an interest in mathematics and technology. He came to the United States at the age of 11, and at the age of 12, he broke his first computer. Daniel was amazed at how computers operate and realized an education in computer science implied a good mixture of his two interests. He studied and worked as a mathematics tutor at San Jacinto Community College, for which he received an Associates of Science in Mathematics. Daniel is a current UHCL NSF Scholar and mentor at the BSC Club at UHCL. Daniel has grown interest in artificial intelligence and would like to continue his education in this field. Aside from school, Daniel is member of a church's youth group and volunteers to community events. During the summer of 2015, Daniel traveled on a missionary trip to Mozambique, Africa. He taught a group of students, professors, priests, and radio broadcasters about video editing and computer repair in an institute called Nacuxa and a local radio station. Daniel wishes to return to Mozambique in the future.

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Miguel Rosales has been a student at the University of Houston-Clear Lake since 2014 and is a senior undergraduate seeking degrees in computer science and mathematics. During his academic career Miguel has coauthored papers under Springer's Microgravity Science and Technology and the First Year Engineering Experience Conference. In addition, Miguel actively conducts robotics research at the University of Houston-Clear Lake, and is president of the National Science Foundation Scholars organization at his university. Miguel's interests include competing in programming and robotics orientated competitions. Miguel will be graduating at the end of this Fall semester and hopes to start working towards a degree in robotics programming.

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Abstract

A team of student mentors has been brought together with the goal of increasing the availability of opportunities for student success and retention as STEM students transition from large urban community colleges to a four-year university. In the first two years of the affiliated NSF STEP grant, known locally as Bridges to STEM Careers (BSC), the mentor team has worked to provide activities for students, including summer orientation sessions, Tech Fridays, mentoring and tutoring sessions, an annual STEM challenge, and BSC clubs on four campuses. Fifteen students have acted as mentors, session leaders, tutors and club leaders. Mentors attend and assist in introductory Computer Science classes, and hold weekly recitation sessions and office hours during which students in a number of mathematics, computer engineering, and computing courses can find tutoring help. In addition, the student mentors encourage student participation in competitions such as design challenges, hackathons, and other STEM related activities outside the classroom. These activities and competitions allow students to network, develop cross-disciplinary skills, build hands on experience, and apply critical skills while being exposed to “real world” problem solving situations. Approximately 140 different students have participated in one or more events, and each event has been assessed by an external reviewer. Mentors from the four campuses have chances to interact during combined BSC club meetings, Tech Fridays and our annual STEM challenge. We propose that a model similar to this could be successfully and beneficially implemented more widely, with the goal of increasing both interest and retention in STEM fields.

Introduction

The goal of Bridges to STEM Careers is to increase retention rates and general interest in the STEM programs offered by the university.¹ The name itself refers to a bridge, reaching from community college, through university, all the way to a successful STEM career. The primary method of achieving this goal has been to forge mutually beneficial relationships among faculty, student mentors, and students. We believe that our goals are best effected on a personal level rather than an institutional level, and that by focusing on individuals we can better help to ensure their future success in STEM-related fields.² This has been accomplished in a number of ways, such as: mentoring, summer orientations, online resources, Tech Fridays, and STEM challenges.³

Bridges to STEM Careers is a cooperative partnership between the University of Houston-Clear Lake and San Jacinto Community College, and the program comprises four campuses in total. The grant committee is composed of Faculty from each campus, as well as partners from local industry. This was done to facilitate closer cooperation among these institutions, as well as a smoother transition for students.

This paper will explore the various activities and events that BSC has engaged in, specifically from the perspective of the student mentors, who were critically involved in both the planning and execution of each of the following areas: BSC orientation, the development of online supporting resources, Tech Friday workshops, tutoring, and the organization of a yearly STEM challenge.

It is important to note that all the events and services provided by BSC are run by the student mentors. The faculty in charge of the program provide the resources needed and ensure that the program is producing valuable results. We, the BSC student mentors, plan the events, decide on Tech Friday topics, manage the website and event registrations, develop activities for our STEM challenge, and write all documents used in our activities, including this paper. We, the BSC mentors, will describe below the services and events we put together and how they achieve helping students' transition to a four-year university in a STEM related field.

Summer Orientation

The team of mentors worked to develop BSC orientation, held one week before the Fall semester. The orientation is broken into two days. The first day is targeted exclusively to students at University of Houston-Clear Lake (UHCL), and San Jacinto College (SJC) organizes their own event for their students. The second day is a joint event between the two. This helps students meet new students from inside and outside their school with similar interests. During our first day of orientation, our schedule was structured based on three main events: the BSC Club presentation, a faculty panel and an online scavenger hunt. We also provided lunch and gave freebies to students.

The BSC mentors gave a presentation as the initial event for the first day of the orientation. It was designed to help incoming students succeed at our university. Throughout the presentation, the BSC mentors discussed different personal techniques used to succeed at UHCL, gained through practical and personal experience. Apart from the main ethical and professional points of avoiding cheating, laziness, and procrastination, we shared very specific tips for various courses. We believe that with this presentation, we were able to give the students an insight as to what life as a university student is like. They learned about their professors before meeting them, about what courses to take in conjunction, and good approaches to take when studying. All this information comes directly from our personal experience. When we first became students here, we didn't have anyone with first-hand experience guiding us advice, which is why we believed passing this information is very valuable. Although students have to take all the courses required, they now know which courses provide a balanced semester. Students have continued to visit the BSC office to ask for our recommendations about the courses they need to take for their upcoming semesters.

After our presentation, we hosted a question and answer session directly with university faculty. Students were given the chance to ask questions about courses, professors, and schedules. This panel included professors from various STEM departments, specifically those who teach freshman-level courses. All professors were able to give great insight into what they expect from students as well as what students can expect from them.

The last event on the first day of orientation was the online Scavenger Hunt. We divided students into groups of at least three students. The objective of this event was to piece together a 100-piece puzzle before the other teams. Based on clues that were given to them by us, their job was to determine the URL for each page that the clue pointed to. We then compared their answer.

When correct, we would give them the next clue. With each correct answer they would attain 10 pieces of the puzzle. The URLs selected were mostly links to web pages that are very important to new university students. We believe that this fun challenge allowed the students to traverse and familiarize themselves with the university's website as well as our own BSC CyberCenter.

Our first event during the second day was another presentation by the mentors, *What we have done and who we are*. We took this opportunity to summarize our organization, including past events that we have organized. We spoke about our past Tech Friday events and gave them a preview of the subjects to be covered in our upcoming Tech Fridays. We then had a small team-building activity which allowed students to "break the ice".

The final event of the day and orientation was another panel. This panel comprised University staff from various departments, such as Academic Advising, Financial Aid, and Student Life. This panel was selected to be beneficial to both new university students, as well as those considering transferring to UHCL in the future. The students were able to ask questions regarding transferring, enrollment, financial aid, and course selection. We believe this panel was a great success, as the students were able to gain a lot of helpful knowledge for their careers as students and beyond.

Online Resources

One of the primary objectives for the BSC program has been to develop a web-based resource for students, designed to complement and publicize our other offerings. In addition to providing access to educational resources, this site is also intended to serve as a way to let students know about upcoming activities and offer a way to get in touch with us, the mentors. This site is known as the BSC CyberCenter, and has been entirely designed and developed by the mentors.

At this point, the site has grown to include all of these functionalities and more. We continually update the site to reflect the activities that are coming up soon, and we also use the site as a way for students to register for our events. The CyberCenter includes registration/account functionality, so that students who register for the site can receive regular email updates about upcoming events and activities. Additionally, members of the site are allowed to register for all of our events before the general registration is opened.

In addition to providing information on upcoming events, we also keep archives of all of our past events, including photos and descriptions as well as tutorials and other resources that allow students to work through educational projects on their own time.

The CyberCenter was developed in PHP using the ModX framework, which provides functionality such as user accounts and authentication, as well as a full-featured back-end graphical user interface which allows the administration of critical site functionality and the simple management of website resources.

Tech Fridays

Every semester, the mentors offer technical workshops known as Tech Fridays. At these events, students are introduced to new technologies, new techniques, and, to some, new areas of interest. BSC has offered Tech Fridays in a wide variety of subjects, including robotics, Arduino,⁴ computer forensics,⁵ responsive web development, circuitry implementation, game development, and video editing.

The main objective of these Tech Fridays is for students to learn something new by working through a small project. We want them to look at a different technology, and at the same time see an example of its application. Typically, students are guided by a lead mentor who put the project together. The remaining mentors provide assistance to students who may require extra help or are behind. Towards the end, students are allowed to modify the given project and try new things. All of the projects use software that is freely available. That way, students are able to reproduce the project and continue to explore the subject in question.

Many students' first interaction with the university, and with BSC in particular, was through a Tech Friday. This is one important function of these events: to get local community college students familiar with the university campus in order to increase their likelihood of transferring. In fact, one of our mentors first participated in BSC in a Tech Friday about Robotics using Arduinos. One semester later, he transferred to UHCL from SJC. He continued to participate in BSC activities and is now one of our mentors. Though he did not know anything about Arduino before that first Tech Friday, he recently developed and led his first Tech Friday over the subject of Arduino and Charlieplexing.

Tech Fridays are entirely developed and led by student mentors, which has been extremely beneficial. In order to plan and execute a successful Tech Friday, one must first ensure that the selected topic is of interest. Like our attendees, we too are students and of a similar major. Therefore, we have insight into which subjects are attractive to STEM students. Because the attendees are of diverse skill levels, a balance must be achieved whereby less experienced students are able to understand and follow the material, while still challenging those with greater experience. To do this, we attempt to select an interesting but uncommon project. This gives us an opportunity to do research and learn something new while putting this event together. In addition, the mentors have a set of diverse skills, and affords opportunities for us to learn new things from one another.

Our goal is for students to enjoy and learn something new in Tech Fridays. Therefore, we try our best to ensure that our attendees are treated respectfully and are given the attention they deserve. To evaluate our work, we hold surveys that help us determine future topics and changes to our overall event structure. These surveys are provided before and after the event. This helps us determine what the expectations of the attendees are and if such expectations were met. Overall, our Tech Fridays have been very successful as measured by survey statistics and increased participation from students. The following graphs show a before and after of a Tech Friday.

Q: My Current level of interest in learning about Charlieplexing is:

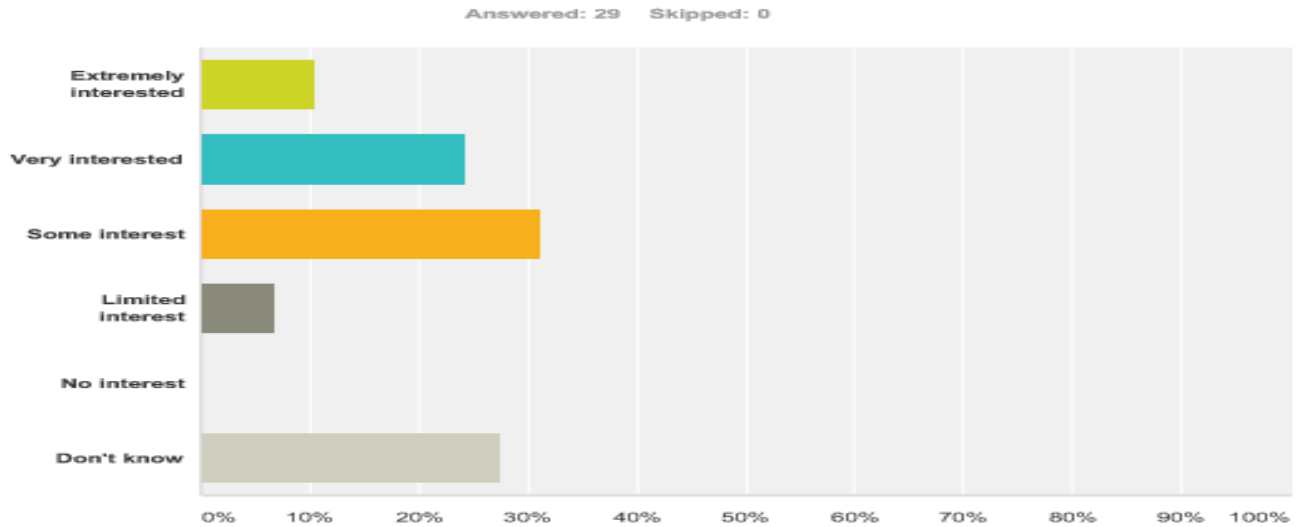


Figure 1. Pre Survey of Charlieplexing with Arduino Tech Friday

Q: After participating in today's Tech Friday, my current level of interest in Charlieplexing is:

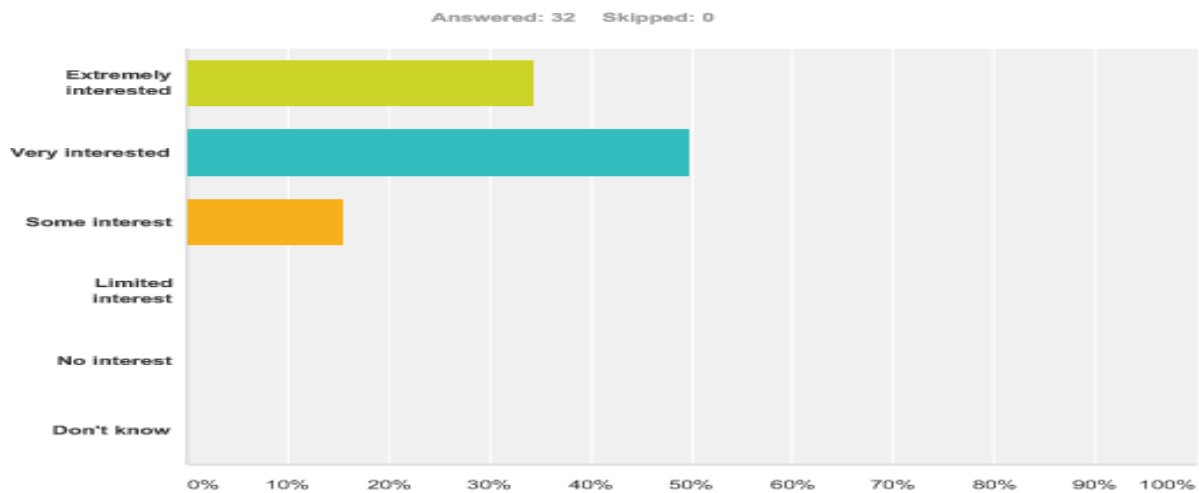


Figure 2. Post Survey of Charlieplexing with Arduino Tech Friday

Student Mentoring and Tutoring

Our mentoring program helps recruit STEM major students from community colleges. As a team of supportive and motivated mentors, we aim to attract other students by setting good examples as successful students in STEM majors.

The goal of our mentoring program is to enable students to develop their problems solving skills and reach their full potential. The mentoring team is composed of different majors from Mathematics, to Computer Science to Computer Engineering. We keep regular office hours which cover most of the school's hours from Monday to Friday, with the goal of helping students to understand difficult problems and show them the way to succeed in class. Many students struggle with the material of beginning engineering courses such as Digital Circuits,

Discrete Mathematics, or Computer Science 1. Mentors help them to understand basic concepts and become independent to solve more challenging problems themselves.

We mentors have also regularly attended the university's Computer Science 1 & 2 courses for Freshmen. This breeds familiarity between the mentors and the incoming students, and promotes the other resources offered by BSC. Mentors attend every class and provide assistance to students in-class in various ways.

Our mentoring program develops students' skills and qualities that remain valuable beyond the duration of the mentoring partnership. As mentors, not only do we help with academic related problems, we are also big brothers and sisters of new students. Starting at the orientation, each student is assigned to a mentor, which allows us to keep in touch with them, follow their continued progress, and offer assistance when needed. We encourage them to pursue and retain STEM majors and share with them the opportunities that might be open in research as well as internship.

The older sibling relationship extends beyond merely reviewing material. The mentors are students themselves and because of this there is a greater chance that the mentees can relate on a more personal level. This level of relationship allows for the mentees to be confident in confiding in their mentors and being directed to the proper channels of support. In addition, the mentors are able to advise students on subject priority as they have also taken the courses. This can help reduce the chances of a student overwhelming themselves with a difficult series of classes in one semester and helps to educate students regarding which classes will require higher prioritization of the individual's time.

Our mentoring program also motivates and engages the school's best students and provides direct opportunity for knowledge sharing. In this way, the mentoring program is extremely beneficial to the mentors themselves. Our mentors have the opportunities to review the material and understand the material enough to explain to others. We also learn and improve their teaching skills, leadership skills as well as communication skills, all of which are very essential for professionals. Our directed mentoring program enables us to motivate and engage the most promising students of the school, as well as those who struggle the most.

STEM Challenge

In addition to the other programs and events offered by BSC, the mentors also plan an annual STEM challenge for students. This is a team-based event that allows students to compete against each other for prizes, including internships and scholarships as well as other prizes such as robotics kits and gift cards for local businesses. This event is sponsored by local industry partners, and provides a showcase for students to demonstrate their skills and teamwork.⁶

The STEM challenge was originally called the Robotics Programming Challenge and consisted of three modules: robotics programming, sensor programming, and a morse-code section. All of the modules were based on programming an Arduino microcontroller using the Arduino programming environment and had multiple sub challenges that built off of each other. This means that to complete the final challenge of a module you would have to complete the first and

following challenges. The aim of this challenge was to encourage the use of critical thinking, interpersonal communication, and teamwork skills by exposing participants to situations and tools that they normally wouldn't experience in a traditional university setting.

Examples and snippets of code were provided to participants in each module so that everyone would have a similar starting point or reference if they ran into a completely unknown situation. In addition, the participants were allowed to ask questions to judges regarding the challenge to verify code. The participating teams were divided into beginner or advanced sections based on prior programming or robotics experience.

The sensor programming module consisted of a variety of sensors and transmission mediums: temperature sensors, water sensors, bluetooth transceivers, LCD displays, and LEDs. Initially teams were to upload a blank code to the board to demonstrate they could interface with it correctly. Then teams had to read proper temperature and detect water from their respective sensor and make an LED change color when certain criteria were met. Following this teams were to display a string of the sensor readings on a display. A bonus challenge for this module was to convert from Celsius to Fahrenheit and display the result on an android smartphone.

In the Morse-code section teams were to program an Arduino board to transmit a message in Morse-code by controlling an LED to blink accordingly. Dot and dash libraries were given to the participants and it was their job to effectively make a library of the necessary letters to transmit their message. Initially the teams would start off by simply making an LED blink. Then the teams were to attempt to get the sequence for a character to be transmitted via blinking. Following this they were presented with the message to be transmitted.

The robotics programming section consisted of programming a mobile track based tank robot to autonomously navigate through an obstacle course for a period of time while avoiding collisions. Initially the teams would start by simply programming basic motion into the robot. Then, the teams would add basic sensors such as an ultrasonic sensor to detect objects in the path of the robot. Following this the teams were allowed to visit the course to plan out their autonomous navigation algorithm. Additionally, there was a bonus challenge to teams that finished early. This bonus challenge consisted of attaching a Bluetooth transceiver to the robot and controlling it using an android smartphone.

Overall, the first challenge was a success and we saw a good retention rate in participants returning for future challenges. We did receive feedback that having programming in every module discouraged participation from certain STEM majors. This resulted in a shift from programming challenge to STEM challenge in all future competitions. The aim is still to encourage critical thinking, teamwork, and interpersonal skills among participants, but programming is now given its own module and the remaining and the remaining modules consist of non-programming based challenges in areas such as mathematics, critical thinking, problem solving, and cryptography.

For our second annual challenge, over 8 different high schools and 6 different community colleges and universities were represented in the challenge. The challenge consisted of two levels of competition, with each team rotating through three stations: Game of Clues to challenge their

math knowledge, Creative Inventors to showcase their imaginative skills and Robot Adventure to test their problem solving and programming skills. The challenge was open to all high school and undergraduate students, and was limited to 18 teams, with a maximum of 4 members per team. 12 beginner teams and 6 advanced teams participated in the event. During the challenge, each team spent 50 minutes at one of the three stations, trying to complete tasks that were progressively more challenging, before rotating to the second and third station. Each task was assigned a point value, and each task had to be completed and demonstrated before receiving instructions for the next task.

Community college, high school and university faculty members participated actively and served as judges and in various other capacities. Industrial representatives from our local industry partners also served as judges. Additional support was provided by various other companies and restaurants in the community.

Conclusion

Throughout all of these programs and events, our focus as mentors has remained the same: to encourage and assist STEM students in reaching their potential by forging personal relationships and offering activities to encourage development and education. We want to provide a comfortable and smooth transition from a community college to UHCL; a transition where the student can focus their energy purely on their education, and receive the appropriate help when needed.

A prominent goal for our future work is to determine better ways in which to measure our efficacy. This will involve continuing to track students' progress using the CyberCenter, and developing new ways of getting informative feedback on our activities. The current feedback that we have is mostly based on before and after surveys, which are distributed to students at each of our events. We only have data from the time since the program started, however, which makes it difficult to determine any statistical changes due to the influence of this program.

What data we do have, however, strongly supports the conclusion that this program has been, thus far, a success. It will take more time to determine any effect in terms of retention rates and transfer rates, but on a smaller scale the feedback has been overwhelmingly positive. The number of students who seek tutoring has increased markedly since the beginning of the program, as has the level of student engagement in our extracurricular activities.

References

1. Abeysekera, K., Davari, S., Yue, K., Brown, E., Kent, M., Betts, P., & Meeks, J., Success through Academic Recognition (STAR): Sustaining and Expanding UHCL and SJC TWD Computer Science Scholar Program, the third annual Texas Engineering and Technology Consortium Best Practices Conference, Dallas, Feb. 28, 2008, pp 7-9. www.theceb.state.tx.us/index.cfm?objectid=8828378A-D358-8867-5E14BDC65C9860B9

2. Chun-Mei Zhao and George D. Kuh, "ADDING VALUE: Learning Communities and Student Engagement", *Research in Higher Education*, vol. 47, 2006, pp 89-109
3. Jolly, Campbell, and Perlman, "Engagement, Capacity and Continuity: A Trilogy for Student Success" (GE Foundation, September 2004)
4. Wiggins, Perkins-Hall, et. al, "First Year Engineering Experience, Resource Management in Completion of an Arduino Engineering Project and Its Industrial Applications", First Year Education Experience Conference, College Station, TX , August 7-8, 2014.
5. Abeysekera, K., Zhang, T., Perkins-Hall, S., Davari, S., "Creating awareness of the field of cyber forensics with a simulated digital crime scene investigation", 19th Annual Colloquium for Information Security Education (CISSE), June 14, 2015, Las Vegas, NV.
6. Davari, S., Abeysekera, K. and Yue, K., "Building STEM Awareness through Programming Competition", the Fourth Annual Texas Engineering and Technology Consortium Best Practices Conference, Austin, February 11-12, 2009
7. American Society for Engineering report, "Going the Distance: Best Practices and Strategies for Retaining Engineering, Engineering Technology and Computing Students" (Washington, D.C., 2012)