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Board 190C: Lessons Learned from the First Offering of REU PATHWAYS Summer Research Program for Community College Students

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Lessons Learned from the First Offering of REU PATHWAYS Summer Research Program for Community College Students

Abstract

Community colleges play an important role in workforce development across the United States as their main mission is to provide academic preparation and skills training to prepare students for jobs or to transfer to four-year colleges and universities. In recognizing the importance of community colleges in workforce development and students training, Northeastern University recently received a National Science Foundation (NSF) grant for a Research Experiences for Undergraduates (REU) site. The site recruits only community college students from the greater Boston area with the goal of preparing students to either join the workforce or transfer to higher education in engineering.

The REU site, called REU Pathways, focuses on smart engineering with four research themes: artificial intelligence and machine learning, smart infrastructure, smart materials, and smart health. Each year, the REU site offers 10 local students the opportunity to engage in a 10-week research experience, for a total of 30 students in 3 years. The external evaluator of the program conducted the first formative evaluation after Year 1 of the program. Results from the evaluation report and lessons learned will be incorporated and implemented into Year 2 of the program. This paper describes the program, the formative evaluation results and our planned improvements for the next 2 years.

Introduction

Community colleges play a critical role in advancing the education of all learners. Approximately 44% of first-time college first year students begin in community colleges [1-3]. Community colleges span the entire US geography and are found in rural, suburban, and urban areas. Community colleges provide a more affordable entry point for higher education for many students from different socioeconomic backgrounds. Community colleges provide instruction in a wide variety of fields including healthcare, cyber security, information technology, business, and manufacturing. Community colleges often train students to meet workforce demands. In addition, they prepare some students to transfer to 4-year colleges.

Northeastern University recently received an NSF grant for an REU site. The site recruits community college students from the greater Boston area with the goal of preparing students to either join the workforce or transfer to higher education. The REU site, called REU Pathways, focuses on smart engineering with four research themes: artificial intelligence and machine learning, smart infrastructure, smart materials, and smart health. The program is guided by two of the grand challenges of the National Academy of Engineering: personalized learning and scientific discovery. For 3 years, the REU site offers 10 students each year with the opportunity to engage in a 10-week research experience, for a total of 30 students. The REU program is a commuter-based program and provides a laptop, a SparkFun Inventors Kit ($100 value), and a

$6,000 stipend to cover meals and commuting expenses. The program recruits traditionally under-represented community college students in engineering such as women or black, indigenous and people of color (BIPOC).

REU Program Elements

Based on the first year of operation, unique aspects of the REU program included: a hands-on workshop in Arduino programming, engineering design, and prototyping; formal mentor training including modules for mentoring URM students; daily student meetings with mentors; extensive professional development seminars; formal research training including daily reflection journals, poster presentations and technical writing with a faculty member. REU students completed two deliverables: a research project and an open-ended Arduino engineering design project. Initially, students chose their research projects from a list of available opportunities. Once a match was secured, students worked in their research labs daily with their graduate student and faculty mentors.

A list of students' engineering research projects included:

1. Accelerating Operations on Graph Neural Network
2. Computational Design of Single Atom Catalysts for Electrochemical CO2 Reduction
3. Information Theory to Pinpoint Causal Links from Complex Data
4. Causal Coupling Inference in Mass Shootings Data
5. Relating Carbon Nanotube Network Structure to Mechanical and Viscoelastic Performance
6. Using Fourier Transforms to Disambiguate Microstructures of Ferromagnetic FeSiB Ribbons
7. Analog Computing Simulation Tool for Machine Learning Inference in Edge Biomedical Devices

For the hands-on workshop, students were provided a free ($100 value) SparkFun Inventors Kit [4], which is used in the host institution's undergraduate curriculum for all undergraduate first year engineering students. For the first week of the REU program, an engineering faculty member taught half-day workshops to introduce students to Arduino programming, all the sensors available in the kit, and engineering design principles. Students visited an undergraduate engineering makerspace to learn what tools were available to them for the summer for their Arduino design projects. Students completed an online lab safety workshop administered by the host institution in order to be certified to use hand tools in the makerspace.

For the engineering design project, students were paired with another REU student and challenged to identify an authentic engineering problem that could be solved with components from their SparkFun Inventors Kit and the prototyping skills they were learning in the makerspace. After the first week, students met with the Arduino workshop professor for 2 hours per week to work on their projects together. They were invited to use the makerspace's 3D printers and laser cutters and any of the free educational software needed to design parts for their project such as AutoCAD or SolidWorks. The theme of their engineering design Arduino projects was "smart" where SMART technology is an umbrella term used to describe interconnected devices that perform relatively normal functions with a greater degree of autonomy than their non-smart equivalents. Students' Arduino engineering design projects included a smart GPS tracking device, a smart lockbox, a smart plant watering system, a smart kitchen ingredient scale, and a smart pillbox medication dispenser. In total, students participated in 15 hours of hands-on learning and Arduino instruction. Despite students varying levels of familiarity with Arduino at the start of the program, all students' projects came together (overcoming some last minute technical hiccups) and all projects were formally presented during the final week of the program (Figures 1 – 4).

Figure 1. Smart kitchen ingredient scale.

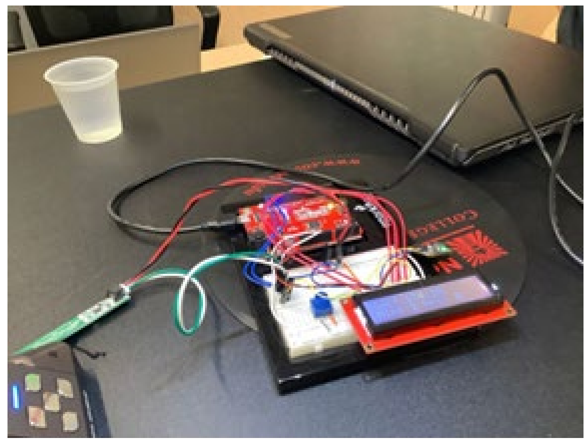

Figure 2. Smart plant watering system.

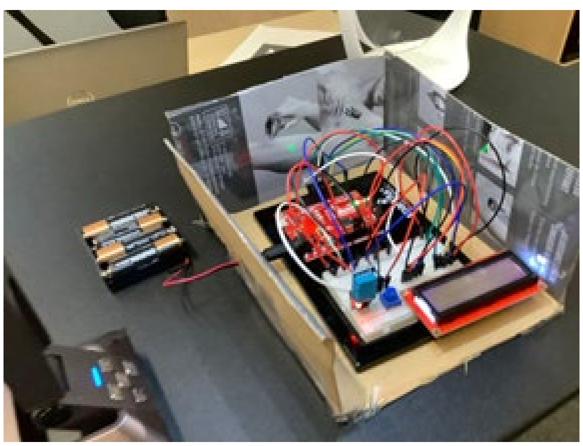

Figure 3. Smart lockbox.

Figure 4. Smart pillbox medication dispenser.

In addition to gaining research experience, students received training on teamwork and communication best practices through a suite of professional development opportunities. Field trips to a biotechnology company and to the university's marine science center provided students first-hand exposure to the STEM workforce and other fields of research in action.

In summary, activities in the REU provide students with the following engineering best practices: (1) conduct independent research to solve a problem; (2) design, develop and test a design project solution for a particular end-user; (3) limit their problem scope in the context of time and resource constraints; (4) learn to work as a part of a team; (5) enhance and improve their technical communication skills; (6) enhance their learning skillset, an important asset for life-long learning; and (7) adapt to fast-moving environments (finish projects in 10 weeks in a new environment), a critical prerequisite to succeed in academics or the workplace.

Student Recruitment and Selection

Students were recruited from 7 local community colleges by leveraging existing relationships and communication mechanisms between the host institution and community college faculty and administrators. The research opportunity was also posted on the host institution's website and shared on social media. Notification of program funding (mid-April) was quite late in the normal REU recruitment cycle, which usually begins in January and concludes in April. As such, only 14 students applied and half were accepted. With such a small applicant pool and specific research fields based on available professors, we were only able to accept specific students, which limited the diversity of demographics we would have preferred (Figures 1 and 2). In addition, three accepted students chose not to participate. The average GPA of applicants was 3.21.

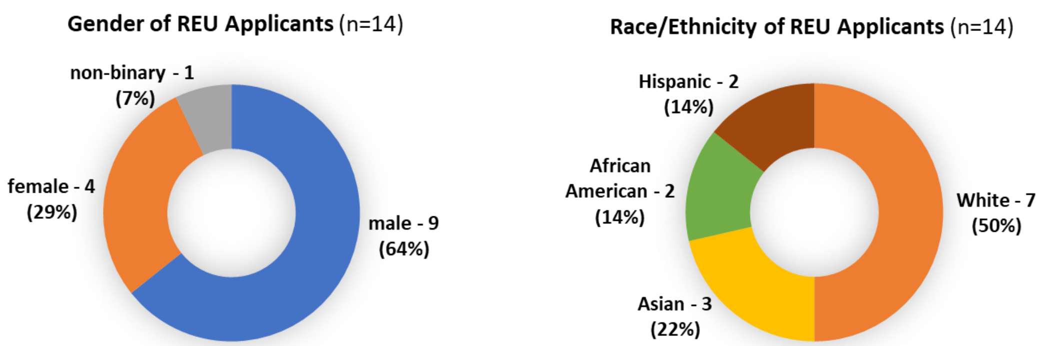

Figure 1. Gender and race/ethnicity of REU student applicants (n = 14).

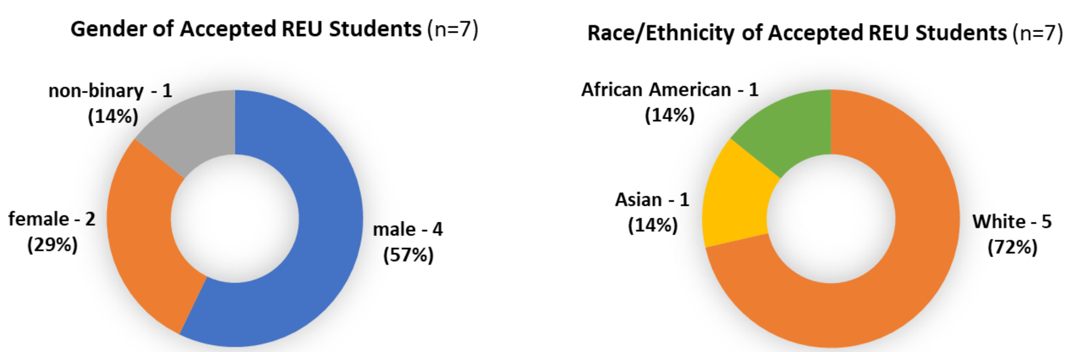

Figure 2. Gender and race/ethnicity of accepted REU students (n = 7).

Evaluation

Student feedback was collected with qualitative and quantitative online surveys after weeks 1, 3, 6, and 9. Each week, coordinators reviewed survey results to improve the REU experience as needed. Formal evaluation of the program was conducted by an external evaluator at the end of the 10 weeks using a pre vs post comparison approach. Mentors also completed a pre vs post comparison approach survey to share their experiences.

Results - Arduino Workshops

Quantitative: Mean: 3.3 | Median/Mode: 4

> *Scale between 0-4: 0 = No Interest/Value <-> 4 = Very Interesting/Valuable*

Qualitative: feedback was mixed: some wanted more time to work on projects whilst others wanted less time. Some preferred partners whilst others would have preferred working alone. However, everyone would have preferred a more informal experience with more student choice (i.e. how much time to commit to projects, what final presentations look like, how strict final project requirements are).

> *"I really enjoyed the Arduino project this summer. I came into the program only having a vague understanding of programming, and am now leaving with a good foundation of fundamentals. Keeping the Sparkfun kit is incredibly valuable to be able to continue practicing and learning more through the projects and am very grateful to receive it."*

> *"Similar to the [energy] workshop, homework or an 'assignment' is a distraction for students who want to treat their lab as a full time job. I think the assignments associated with these projects should be less prioritized. Give students the opportunity to present their work, but making it mandatory was something the students found very stressful. Ten weeks is not a lot of time to get on board with a research project, much less that, other parts of the program and a 'smart' project, which is honestly very unlikely to reach completion. Otherwise though, I think this workshop is a great idea."*

Faculty Research Presentations & Skill Building Workshops

Faculty members from across the host institution were invited to present their research and academic journeys. These 1-hour lunch seminars included presentations and question/answer with the students, and in some cases hands-on activities. Due to the students' workload with research and required workshops, these presentations were optional but students were strongly encouraged to attend. Topics presented by engineering faculty included a Diversity Workshop, circuit puzzle design, quantum computing, origami-based human liver models, diamonds: turning defects into sensors, Big Data, social justice, and cell biology. Interest in these faculty research presentations was mixed. Most students enjoyed the sessions (4/7), while others would have preferred more free time (1/7) or presentations more focused on their specific fields (2/7).

In regards to the skill building workshops, students found the sessions on public speaking, poster building, and the Big Data Analytics Course most beneficial. The students found the engineering design build activities fun and refreshing, but not informative.

> *Enjoyed: "I found the lectures I went to interesting. Since they were so much more different then what we were doing in labs it made for a nice break in thinking."*
>
> *Free time: "While a couple of them were interesting, I felt that the time would have been better spent having a break from work. I frequently had very busy days in the lab, and it helps to take a break during lunch. Not having that break usually meant I was tired through lunch and exhausted at the end of the day."*
>
> *Other fields: "For REU attendance anyways, considering our platform was structured around engineering, there were some talks that just really weren't applicable to what most people were working on. I appreciated them being optional attendance as they were sometimes more geared towards the [concurrent high school student research program] who might still be trying to figure out what avenues of STEM they even seek out. Some talks were a lot more applicable and garnished inspiration from participants."*

Mentor Evaluation

In order to ensure mentors were adequately trained to support students placed within their laboratories, an introductory mentoring session was offered for all mentors. In this session, mentors discussed what it took to be a good mentor, including but not limited to: patience, making time for mentees, providing hands-on opportunities, being respectful, strong communication skills, being approachable, fostering independence in the research environment, and instilling self-confidence as well as intrinsic motivation. Later, these traits were addressed in a mid-program assessment.

> When asked to rate the overall quality of their mentoring, mentors rated their overall quality on a 1-5 scale, with an average score of 3.9. When asked if they felt they were meeting their mentees expectations most mentors felt they were fully meeting expectations of participants (3.9/5). Notably, the graduate mentors rated their ability lower than the professors.
>
> *Change was rated on a positive/negative axis: -3, -2, -1 representing large to small negative changes, 0 representing no change, and +1, +2, +3 representing small to large positive changes. Recorded below is the average change from all respondents.*
>
> Please rate how the following changed as a result of your time as a mentor for REU

(+1.7) Working effectively with mentees whose personal background is different from your own
(+1.6) Taking into account the biases and prejudices you might bring to the mentor/mentee relationship
(+1.6) Understanding your impact as a role model
(+1.4) Considering how personal and professional differences may impact expectations
(+1.3) Working with mentees to set clear expectations of the mentoring relationship
(+1.3) Establishing a relationship based on trust
(+1.1) Provide constructive feedback
(+1.1) Identifying and accommodating different communication styles
(+1.1) Aligning your expectations with your mentees'
(+1.1) Accurately estimating your mentees' ability to conduct research
(+1.1) Employing strategies to enhance your mentees' knowledge and abilities
(+1.1) Motivating your mentees
(+1.1) Building mentees' confidence
(+1.1) Acknowledging your mentees' professional contributions
(+1.0) Active listening
(+1.0) Helping your mentees set career goals
(+0.9) Accurately estimating your mentees' level of scientific knowledge
(+0.9) Stimulating mentee's creativity
(+0.7) Helping mentees develop strategies to meet goals
(+0.7) Negotiating a path to professional independence with your mentees
(+0.6) Working with mentees to set research goals
(+0.6) Helping your mentees network effectively
(+0.6) Helping your mentees balance work with their personal life
(+0.4) Coordinating effectively with your mentees' other mentors
(+0.3) Employing strategies to improve communication with mentees
(+0.3) Helping your mentees acquire resources

Mentors strongly approved the administrative support from program leadership (coordinators and staff).

Rating for the following was also on a positive/negative axis: -2, -1 representing level of disagreement, 0 representing neutral, and +1, +2 representing level of agreement. Recorded below is the average from all respondees.
(1.9) I was happy with the quality of the students working with me
(1.9) I was happy with the diversity of students selected to work with me.
(1.1) My students were well-prepared to perform research
(1.0) My students were well-prepared to make technical presentations
(0.6) My students had sufficient experience in computing to support their work

Lessons Learned and Planned Actions

The formative evaluation of Year 1 of REU-PATHWAYS as well as the grant teams revealed some interesting insights:

- There is need for REU participants to feel they belong to the program. We will add a home room meeting every morning in Year 2 and Year 3.
- Given that the community college students all commute to campus, a physical space is needed as a "homebase" to provide a communal location for interactions outside of their research labs.

Conclusions

Based on the results from this final program evaluation, the REU-PATHWAYS program has achieved many of the goals outlined for this project including but not limited to:

- Recruiting a diverse representation of REU students.
- Continuing to support the development of a mentoring ecosystem.
- Engaging participants in authentic research experiences over a 10 week period.
- Improving students skills in programming and engineering design.
- Providing information and resources regarding graduate student pathways in STEM.

In the coming years we plan to expand the REU program to additional students each summer and build upon what we have learned from student feedback this year to improve the experience for all.

Acknowledgements

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