ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #36630

Work in Progress: High School Student Training in Biomedical Engineering Innovation through Co- and extracurricular Activities

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Introduction

Rapid technological innovations and changing needs of the technical workforce require engineering students to gain both disciplinary depth and interdisciplinary and interpersonal skills to ready themselves for the evolving career landscape. Specifically, engineering students are expected to build relevant skills through experiential learning opportunities [1]. However, for most high school students considering engineering in college, their preparation is typically advanced placement courses in science and mathematics. Courses alone don't meet the increasing national demand to better prepare high school students for careers in technology and manufacturing [2]. To bridge this gap, high school students may pursue the skills and qualities expected of them in a university setting, which will enable them to be both knowledgeable about engineering and gain the skills needed for successful college experiences and careers [3].

We, the partnering university and high school, aimed to resolve the paucity of opportunity through the development of co- and extracurricular programs that provide exposure and training in engineering design and innovation to high school students. Through such programs, we hope to help students connect their classroom learnings to their interests and long-term career goals. This effort is a part of a larger vision of the BioInnovation and Design Lab that serves as an interdisciplinary hub for healthcare and biotechnology innovation at Santa Clara University (SCU). The Lab partners with industries to source real-world engineering problems and engages multidisciplinary teams to apply design thinking and entrepreneurial skills to solve problems across biomedical fields. The inter-institutional partnership addresses the current perceived disconnect between high school concepts and college and career preparation, as noted in the literature and captured by the expressed and latent desires of students and faculty [2-5].

Objectives and Value Propositions

Several successful examples of college-K-12 partnerships have demonstrated that a focus on professional development, academic pathways, and after-school activities can help with increased graduation rates, as well as prepare students to better transition to college [3,6]. Building on these ideas, we developed a partnership, with a focus on the intersection of engineering and healthcare, to expose and prepare high school students for career pathways in this evolving field. Through this partnership, we expect the following outcomes: (a) provide high school students exposure to real-world applications and university level experiences, (b) provide university students an opportunity to mentor high school students, and (c) equip high school and university students with technical and interpersonal skills that prepare them for their future careers. Participant evaluations will be used to measure the success of these outcomes, as well as to guide continuous quality improvements. Success will be confirmed by student reports that the experience informed them of their career path in the healthcare industry, and increased their awareness of the role of engineering technologies in this field. Evaluations will be differentiated to (a) determine the relevance of the experiences for college and high school students, and (b) identify knowledge and skills gaps that may exist for different levels of preparation.

Current Efforts and Next Steps

As a first step, we set up a pilot with Saint Francis High School (SFHS). SFHS has an invested interest in providing opportunities to empower students to connect their learning to beyond the campus, for example by creating an innovation center that integrates real-world experiences into their curricular and co-curricular training. Through the partnership, we offered two technical projects for the high school students – machine learning models for disease forecasting using open-source software (ML Project) [7] and biofeedback in virtual reality immersive environments (VR Project). We also established a mentorship program that provides students opportunities to explore emerging engineering innovations and technologies in healthcare through a combination of co-/extracurricular activities and networking opportunities. We targeted students from underrepresented groups, with limited exposure to medical devices, biotechnology, and other healthcare areas, and with different levels of study. Through these efforts, parity was achieved by gender and grade level across the different projects. Given the project scope (i.e., ML, open-source data, VR, biosensors, etc.), we recruited students with intermediate experience in electronics, programming, or design for the technical projects. We reached out to students through tech-focused clubs and computer science courses (7 students recruited for the ML Project and 9 students for the VR Project). For the mentorship program, we sought more novice students in their freshman or sophomore year, who have not yet had exposure to fields or careers in technology and innovation in the service of healthcare to apply (11 of 43 applicants accepted).

The sub-sections below provide additional details on these efforts, and discuss the progress achieved thus far and possible next steps:

1. ML models for disease forecasting: In the first pilot project, SFHS students participated in a five-week project with the SCU student team during the summer. The project focused on predicting future trends in infectious diseases using publicly available data. High school students furthered their knowledge in machine learning and R programming by analyzing datasets and models that were generated by the SCU students,[7] who met with the team weekly for topical discussions. The project culminated in a presentation for the high school and university administrators, project mentors, and parents. This pilot laid the foundation for future efforts both by informing us of optimal strategies to recruit students, e.g., through appropriate clubs and courses, and how to better design the project experiences and training to support skill development and original contributions from students.

2. Biofeedback in VR immersive environments: For the academic year, an experiential learning opportunity that explores mental health and technology was implemented. A team of students with electronics, programming, and design interests is creating a biofeedback VR application. The students are building an Arduino pulse sensor, designing an interactive VR experience (which applies principles of psychology, art, mathematics, and programming), and then integrating those elements. The students, all new to game design, are earning certificates in Unity3D development and participated in a personalized workshop by a professional VR designer. The VR experience will be a live installation for peers to try, and a presentation to an audience of the high school and university faculty and industry professionals in May 2022.

3. Healthcare Innovation mentorship program: The mentorship program supports eleven high school students who are interested in learning about challenges in healthcare and provides them with opportunities to see what their future path could be. Students selected for this program (a) attend a seminar series hosted at SCU, (b) participate in quarterly group meetings with a faculty mentor, and (c) write a reflection paper. Towards the end of the mentorship, students will participate in a design challenge, working in teams to rapidly prototype, iterate concepts, and present potential solutions to an important healthcare problem.

Program success was measured by following continued student participation, and attainment of the technical skills described above. Student comments also illustrate how curiosity in the subject matter grew, greater self-discovery by working with a diverse team emerged, and strengthened confidence through effective problem-solving. In combination, these reflections are early evidence that the experiential learning platform created by this partnership will better prepare students for collegiate engineering programs. The impact of different structured experiences will be assessed by exit interviews of the high school and college students to determine whether the partnership effectively met the stated objectives.

Our next steps are to introduce students to additional technical areas within engineering that contribute to healthcare. We aim to scale this partnership model by developing a consortium of universities, high schools, and industry partners that provide students with experiences that build towards careers in biomedical and healthcare engineering. We also look forward to sharing the program as a model for engaging and empowering high school students that could be replicated at other universities.

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