2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34128

Developing a Pathway to Post-Secondary Study of Engineering for Underrepresented Secondary Students (Work in Progress, Diversity)

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Jason Coleman, is the Executive Director and Co-Founder of Project SYNCERE. Jason is a veteran engineer and STEM education leader with more than 20 years of experience. As the Executive Director of Project SYNCERE, he has grown the organization to become the largest youth serving STEM organization in Chicago, serving more than 3,500 students annually. Jason is currently serving as the Project Director on a recent Department of Education EIR grant that Project SYNCERE received to support their ENpowered engineering program. Jason has been instrumental in the design and implementation of programs and strategies that have changed the trajectory for thousands of high needs youth throughout Chicago.

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I. Introduction

There is no question that engineering and other STEM careers are at the center of our country's success. In recent years, the United States job market has seen growth in many engineering sectors, but the number of engineers available to fill this need has remained stagnant. Engineers stand at the forefront of developing the nation's innovation as well as sustaining our ongoing development [1]. The ratio of STEM jobs available to the number of trained, qualified applicants is 13 to 1 [2]. In Illinois, the ratios were as high as 18 to 1. The percentages of women and underrepresented minorities is disproportionately lower, a fact that has captured the attention of the nation's science communities and highest levels of government. "The challenges to the national competitiveness and sustained STEM global leadership can be better met through the full utilization of all of the nation's talent and resources [3]."

Project SYNCERE is working to fill this void through its multi-year engineering program, E-CADEMY. E-CADEMY providing students in grades 6-11 with a guided pathway of opportunities that are aimed at developing their skills and interest in the STEM fields to ensure their success at the post-secondary level and beyond. The fundamental principles of E-CADEMY are based on a combination of best practices from research including: a project-based learning (PBL) curriculum, high dosage model, cohort of like-minded peers, engagement with STEM professionals, and family engagement [4]-[8]. This paper provides an overview of the program's component, student feedback and program model future considerations.

II. Program Overview

Project SYNCERE has provided equitable hands-on engineering experiences for more than 20,000 underrepresented students in grades three through twelve since 2011. The goal of the organization's work is to create pathways for underrepresented students to pursue STEM careers through its in-school and out-of-school time engineering programs. In 2016, after four years, the organization revamped its 10-week middle and high school Saturday Program, Emerging Engineers into a 32-week Saturday program that ran the entire academic year. The first year of programming was only offered to 6th and 7th graders and 9th and 10th graders. Each year an additional class was added for both middle and high school.

In addition to changing the program length, more ideas were added to enrich the program offering such as teacher training, standardized curriculum, increased field trips, and interactions with more STEM professionals. The organization felt these changes would directly affect programming outcomes in the area of student desire to pursue STEM careers, as well as, their preparedness to matriculate through a traditional college of engineering program of study. The program leverages the robustness of the nationally recognized Project Lead the Way (PLTW) curriculum to teach and develop students' skills in engineering, while also leveraging corporate/community partnerships to provide the necessary exposure to STEM professionals, facilities, and campuses. To date this is the only year-round engineering focused program in Chicago. E-CADEMY is also the only non-school affiliated organization to use PLTW in Illinois, as well as the only organization in the state to implement PLTW during out-of-school time.

1) Students & Selection

Participation in the E-CADEMY program is by application and interview. Students apply from across the city and surrounding suburbs. Students who are targeted to take part in the program primarily live-in neighborhoods that are identified as having a large percent of African American and/or students of Hispanic heritage. Student applications are heavily weighted on student interest in STEM through their interview and essays, and less of an emphasis on grades and prior performance in STEM classes or clubs.

The program started in 2016 with 28 middle schoolers and 6 high schoolers across two classes, and now in 2021 has 60 high schoolers and 20 middle schoolers across five classes. In the current year, 78% of the students are African American and 15% are of Hispanic heritage. 57% are male and 42% are female. The program saw a significant dip in middle school students due to COVID-19 but did not see the same decline in high school enrollment.

2) Program Activities

E-CADEMY is the only year-round program in Chicago, which offers students an opportunity to scaffold their learning from middle school through high school to set the groundwork for their completion of post-secondary study and entry into engineering careers. The year-round program runs for 32-weeks on Saturday during the academic year for both middle and high school students, while also providing high school students with an additional 6-week apprenticeship during the summer.

Each Saturday, pre-COVID, middle school students met for 4.5 hours, while high school students met for 6 hours. The middle school (Gateway) and high school (Pro) groups, each consist of three cohorts of 20 students. Students join the program during their middle school years, 6^{th}-8^{th} grade, or during their 9th or 10th grade year of high school. This intentional process allows the program to have students in the program for a sustained period to scaffold their learning, build community through cohorts and create the necessary interventions to develop them for a successful future in STEM. Weekly class sessions take place in rented classrooms in a large underutilized private school. Each classroom was renovated and updated to meet the program needs. In addition, a maker space is in the process of being built.

a) PLTW

It is well documented that PLTW curriculum has effects on students' preparation, interest, and motivation to pursue engineering as a career [9]-[11]. The diversity of students that have access to PLTW programming or choose to sign-up for programming available to them is not as well documented. In the city of X where this program is located, many of the active PLTW programs are in more affluent schools, and the programs that exist in neighbors where this program's participants live are inactive or looking for qualified instructors. One teacher, recently hired to teach a PLTW program within the city who was also hired to work this program, noted that he was hired to do the job, but there were no funds to buy any of the materials required to effectively teach the course at his school. There are also students who enroll in the Saturday program who have already taken a particular PLTW course at their high school, but reported the experience they had participating in the class on Saturday was much more engaging, so much so, they did not feel like they had taken the same course twice. Offering this curriculum on Saturday gives more students an opportunity to learn the content without fear of it affecting their grades, eliminates pre-requisites that schools may impose on the various courses, as well as offers an opportunity to take a class they might not have otherwise signed up to take. Lastly, the

curriculum is largely modified to fit an informal learning environment by emphasizing the hands-on components of the curriculum.

b) Field Trips

Each year students visit engineering companies and at least one engineering campus that is within three-hour drive of the program location. All students go on college visits, and the field trips are coordinated by year in the program. Year one students attend field trips with engineering design firms and lab that expose student to various aspect of engineering, while a third-year student may attend a field trip directly connected to their course content. For example, the digital electronics students will visit a company directly involved in electronics such as Molex, Motorola, or Shure Electronics. All the trips are held on Saturdays.

3) Teachers

Project SYNCERE recognizes the inadequacies in our educational system and employs reverse tactics to engage students in their learning. Project SYNCERE's team of instructors consist of engineering professionals and graduates, state certified engineering or science teachers and college engineering students. Each staff member is certified in the PLTW curriculum and is \ paired with their co-instructor to lead the program. It is the aim of the program to find staff that represent the students through background and/or identity. The current staff of eight is 50% female and 50% male, 50% African-American, 25% Caucasian, 13% of Hispanic heritage, and 12% multi-racial.

3) Parents

Parent engagement is an integral part of students' success. In E-CADEMY, we help parents see the value of their students' participation in the program and what the 'light' at the end of the tunnel can be. Parents are included in field trips to learn more about current STEM applications. Workshops and informationals are also held for parents covering topics such as how to select the best high school for your student, how to support your student's STEM interest at home, and information about upcoming engineering camps or programs that may benefit their child.

4) Subject Matter Experts (SMEs) / Role Models

To add to the authenticity of the program model and to connect the work back to STEM career paths, the program partners with local engineering companies and volunteers to visit with students at least monthly. During the visits, SMEs introduce themselves to students, share information about their current profession, talk with students about the importance of the work they are doing and work with students on their current projects. Through these partnerships, SMEs provide guidance and serve as role models for students. The program is looking to expand the SME role into STEM Coaches/mentors during the students' junior and senior years, by pairing small groups of students with the same volunteer who can serve more as a coach to help students define their STEM interests and better align those interest with their post-secondary program choices.

5) External Partnerships

Both corporate and community partners work to host developmental sessions for students. Some of these sessions focus on helping students create and develop resumes and

LinkedIn accounts to document their successes from the program and begin their professional online portfolio. Other sessions may focus on helping students map out their future career trajectory and the additional things they can do for advancement. External partners may also provide scholarships and opportunities for students to intern or take part in programming and camps at their respective organizations or campuses. During the students' junior and senior in they are connected or recommended to partnering organization who focus on college preparation and success. Partnering organizations also supply small $600 - $750 stipends to high school students who regularly attend the program.

6) COVID-19

In the wake of COVID-19, the program has seen its highest high school enrollment to date, even though a virtual model was adopted. The virtual model includes middle school students meeting weekly for two hours and high schoolers meeting weekly for three hours on Saturdays via Zoom or Google Meets. All project materials were provided to students at the start of the program. Materials included computers, tablets, tools such as calipers, scissors, multi-cutters, VEX robotic parts, breadboards, and electrical components, as well as, consumable materials like tape, glue, balsa wood and craft supplies. High school students still received a stipend for regular class attendance, and SMEs visits and field trips were conducted virtually. Virtual field trips to date have consisted of college tours, virtual STEM fairs hosted by local universities, live engineering lab tours, and skill building workshops such as a sketching with designers from a local product development company.

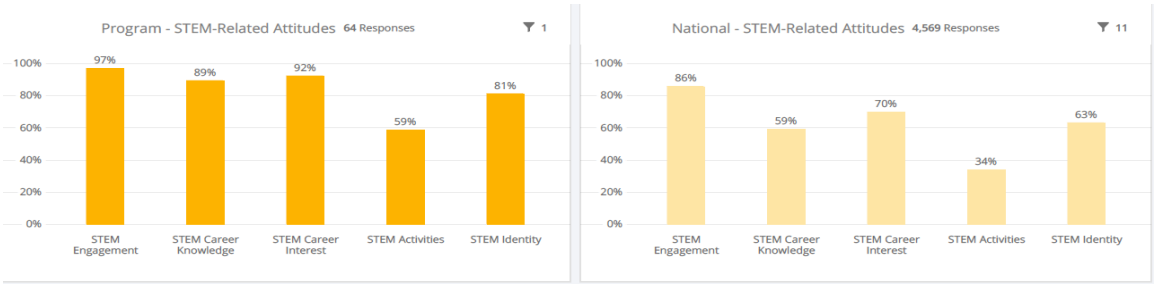
7) Costs

70% of the program is supported through donations from corporations and corporate foundations, 13% of funding comes from non-corporate foundations, and the last 17% comes through government and non-profit grants. The high school portion of the program is free and students receive a stipend to participate. The middle school portion has a yearly cost of $0 to $500 based on family size and income. The overall budget for the program in 2019-20 school year was approximately $436,000 based on 10 instructors, 6 classes and 100 students across middle and high school programs in addition to all materials, rental space, lunch, transportation and personnel costs. The 2020-21 budget is estimated at $375,000 adjusting line items affected by COVID-19, in particular reduced enrollment, instructional hours, lunch and transportation costs.

III. Assessment & Results

The student feedback for this program was informed by the PEAR Institute's Common Instrument Suite (CIS) survey, which presents questions across nine areas divided into two main categories, STEM-Related Attitudes and 21st Century Skills [12]. The CIS tool is used in over 200 out-of-school time STEM programs across the United States. CIS surveys were administered using a retrospective self-change method, which entails giving the survey once to students at the end of the program. Each survey question asked students to think back to the beginning of the program to rate whether they do/feel things less or more now because of the program. Highlighted results from the 2017-2019 (n=64) found most students reported a positive change across all nine categories, even when compared to a national sample. Five of the nine categories are shown in Figure II.

Figure II. Number of students reporting a positive change across STEM Related Attitudes Compared to a National Sample



In addition to questions presented on a Likert scale via the CIS tool, students were also able to supply their thoughts via free response. Students were asked what they would tell a news reporter about their program experience if asked.

- "I'm inspired to push myself to expand my knowledge in STEM topics much more than before." - 2nd year student
- "[This program] gave me the opportunity to explore STEM in a way that my school doesn't" - 3rd year student.
- "Project SYNCERE has had a positive impact on me. It has helped me realize that I do want a career in engineering" - 5th year student.
- "It opened my eyes to a whole new world" - 1st year student.

1) Retention

Further analysis needs to be done as it related to retention. Given the program added two classes each year for the past four years and did not start the program with two full cohorts of students, it is difficult to precisely determine retention. However, in 2021 30% of the 2016 middle school class (n=28) are still enrolled in the program, and 50% of the 2016 high school class (n=7) graduated from the program last year. Several factors contribute to the flux in participation, including change in family support, needing to leave the program once old enough to work an hourly job to provide additional family income, exploration of other interests, and moving to a virtual schedule in Spring 2020.

IV. Conclusion & Considerations

The E-CADEMY program, has shown promise in exposing diverse middle and high school students to engineering careers and practices while increasing their interest and confidence in pursuing engineering as a future profession. Given the age of the program, there is no data on success rate of students matriculating through higher education, although over half of the graduating seniors to date have chosen an engineering career path by applying to an engineering program at a post-secondary institution. Post-secondary data collection is a part of future study plans.

Key considerations from the first four years of this program include ensuring key partnerships are established with organizations like the National Society of Black Engineering, the Society of Hispanic Professional Engineers or employee resource groups to ensure visiting professionals and SME represent the students participating in the program. Additionally, we've found that offering high school students stipends eases the burden older students have to make between doing extracurriculars on Saturday versus getting a formal part-time job.

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