Expanding STEM Engagement Through an Afterschool Renewable Energy Program: Year 3 Insights from an NSF ITEST Project

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Introduction

The SUPERCHARGE (STEM-based University Pathway Encouraging Relationships with Chicago High schools in Automation, Robotics and Green Energy) Project is an NSF ITEST-funded project designed to engage high school students in an afterschool STEM and engineering program. The project is led by a team of faculty and staff at Illinois State University and the University of Missouri – St. Louis. The project is guided by the STEM Learning Ecosystem framework and involves collaboration among faculty and students, high school educators, and community-based organizations at four high schools in the Chicago Public Schools district. The program aims to foster STEM and engineering identity development and sustained interest in STEM fields through hands-on learning and exposure to real-world applications.

The closely-linked concepts *of STEM Identity* and *Engineering Identity* include recognizing oneself as a STEM or engineering person and feeling a sense of belonging in the field of STEM or engineering. It is sometimes defined as seeing yourself as a "STEM person" or an "engineering person." These identities are composed of at least four factors: i. self-recognition, ii. feeling recognized by others, iii. interest in related topics, and iv. self-efficacy and a feeling of confidence doing related tasks [1]. Development of a STEM or engineering identity has been shown to be a significant indicator in educational and professional persistence [2]. Numerous studies cite the importance of role models in the formation of a STEM or engineering identity [1,3,4]. Meanwhile, participation in an afterschool club has been shown to predict STEM career intentions [5,6].

Program Structure

During the 2024–2025 academic year, students in the SUPERCHARGE program participated in afterschool activities spanning four distinct but interrelated topics: 1. Solar Energy, 2. Smart Home Technologies, 3. Solar Technology Applications, and 4. Construction of Dual-Axis Solar Tracker Cart. Students met after school once per week for approximately ninety minutes and were mentored by a team of two to three teachers at their school. Weekly activities included building solar circuits, programming microcontrollers, designing and building model smart homes, and constructing mobile dual-axis solar trackers on the platform of a garden wagon. The curriculum was supported by enrichment events such as teacher professional development workshops, a campus visit featuring prominent YouTube science and engineering influencers, a spring workshop focused on assembly of the mobile dual-axis solar tracker, a field trip to a utility-scale solar farm and interactive energy museum, and a summer STEM camp focused on video game design.

In the third year of this project, the team implemented the after-school curriculum that had been developed during the second year of the project. Activities included four units, with four to five activities in each unit. The units and activities were:

Table 1. Units and weekly after-school activity topics

Unit 1: Solar Energy	Unit 2: Party House
1.1 Electric Grid Card Game	2.1 Wire Loop Game
1.2 Forms of Energy with micro:bit	2.2 A Smart Way to Keep Cool
1.3 Lights, Camera, Action!	2.3 Light Dial Servo Meter
1.4 Solar Energy 1: Solar Circuits	2.4 RGB LED
1.5 Solar Energy 2: Singing Circuits	2.5 Smart Tiny Party House
Unit 3: Solar Technology	Unit 4: Solar Tracker cart
3.1 Where is the Sun? Heliodon	4.1 Cart Construction
3.2 Unplugged Solar Tracker	4.2 Solar Tracker Frame Build
3.3 Desktop Light Tracker Part 1	4.3 Electronics
3.4 Desktop Light Tracker Part 2	4.4 Code & Programming

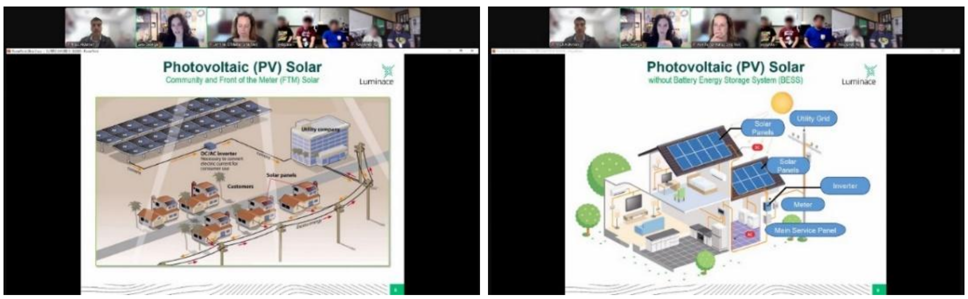
Program activities included:

- Once-per-week 90-minute after-school activities focusing on micro:bit programming, energy, sustainability, and robotics. Activity instructions were provided via the project website.
- October 30, 2024: On-campus visit to Illinois State University for campus tour, lab tour, and special event featuring three prominent YouTube engineering influencers. Attendance = 94 high school students + 10 teachers.
- March 11, 2025 – Hands-on workshop in downtown Chicago at Harold Washington College to guide students as they begin construction of the solar dual-axis tracker project. Attendance = 29 high school students + 8 teachers.
- May 13 and May 15, 2025: After-school guest speaker from Brookfield Renewables discussed renewable energy, jobs in the sustainable energy industry, and introduced the solar project that students will tour on May 22nd. Attendance = approximately 20 high school students + 8 teachers.
- May 22, 2025 – field trip to Brookfield Renewables' utility-scale solar project in the morning and ComEd Powering Lives Community Center in the afternoon. Attendance = 18 high school students + 6 teachers.
- June 11, 2025 – teacher Professional Development workshop for teachers, focusing on the following year's (2025-2026) after-school activities. Attendance = 6 teachers.
- June 16, 205 – summer student workshop at Breakthrough Urban Ministries (community-based partner organization) focusing on students creating their own video games using micro:bit programming. Attendance = 11 high school students + 2 teachers.

Undergraduate student mentors were involved in curriculum development and workshop facilitation. These students reported increased confidence in supporting high school learners and a deeper appreciation for inclusive STEM education. Teacher participants reported improved comfort and awareness of STEM domains, though some identified challenges in preparing students for workforce readiness—insights that are informing future professional development efforts.

(a) (b) (c)

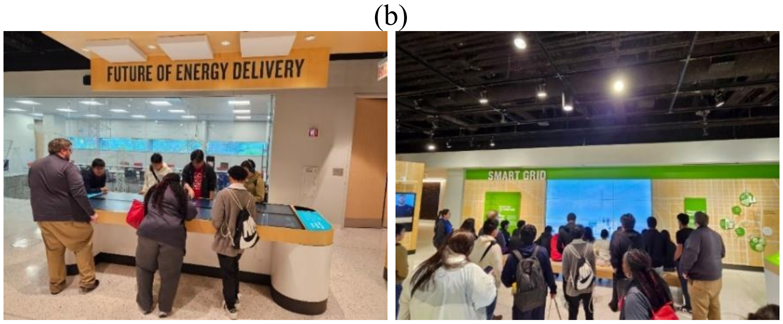
Figure 1. (a) Students attending a full-day workshop on March 11, 2025 work in groups to begin assembly of the dual-axis solar tracker, and (b) listen to guest speakers about renewable energy career opportunities. (c) A few months later, students completed assembly, programming, and testing of the dual-axis solar tracker at their own schools.



(a) (b)

Figure 2. (a, b) On May 15, 2025, students listened to a guest speaker from Brookfield Renewable Energy in preparation for their field trip to solar project the following week.

(a) (b) (c)



(d) (e)

Figure 3. (a, b, c) Students attended a field trip to a Brookfield Renewable Energy solar project on the morning of May 22, 2025. (d, e) Later that afternoon, students visited the ComEd Powering Lives Community Center to learn about Smart Grid technologies.

Data Collection and Assessment

Assessment data was collected through pre- and post-program surveys and interviews. The PEAR CIS-S survey was given to participating students at the beginning of the academic year in fall 2024 and again at the end of the academic year in spring 2025. The survey responses revealed notable growth in student engagement, career interest and curiosity about STEM disciplines. The results of three representative survey questions are shown numerically in Table 2 and graphically in Figures 4 – 6.

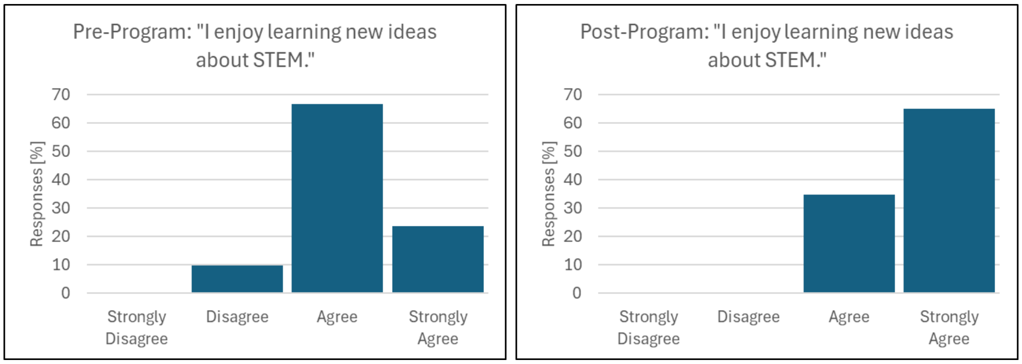
On a five-point Likert scale with 1 being "Strongly disagree" and 5 being "Strongly agree", the average response to the three survey questions in Table 2 showed significant increases over the program year, with the largest gain shown in response to the question "I think of myself as a STEM person." This is noteworthy, as self-identification as a STEM person is a key component of the development of a STEM identity. Smaller but still notable increases were observed in response to the questions "I enjoy learning new ideas about STEM" and "I would like to have a STEM job in the future." Career aspirations identified by the students spanned engineering, game design, and medical fields. Students also reported gains in 21st-century skills such as teamwork, problem-solving, and communication.

Table 2. Responses to selected representative CIS-S survey questions before and after the after-school program.

Pre- vs. Post-Program Survey Results	Mean	Median	Std. Dev.	n
"I enjoy learning new ideas about STEM."				
Pre-Program	3.14	3	0.56	72
Post-Program	3.65	4	0.49	23
"I think of myself as a STEM person."				
Pre-Program	2.32	2	1.01	68
Post-Program	3.22	3	0.67	23
"I would like to have a STEM job in the future."				
Pre-Program	2.97	3	0.79	72
Post-Program	3.35	4	0.83	23

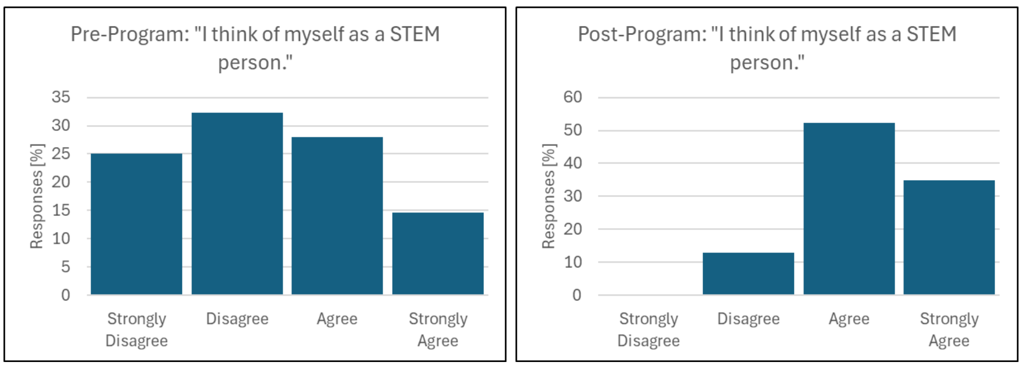
Conclusions

The third year of the SUPERCHARGE project demonstrates the impact of hands-on STEM engagement in shaping high school students' identities and aspirations. Through an afterschool program centered on renewable energy, microcontroller programming, and real-world applications, participants not only gained technical knowledge but also developed skills such as teamwork, problem-solving, and communication. Survey results revealed significant growth in STEM identity, with the largest increase in students' self-recognition as "STEM people" - a key predictor of persistence in STEM pathways. These findings underscore the importance of learning environments that combine mentorship, authentic experiences, and enrichment opportunities to foster confidence and belonging in STEM fields.



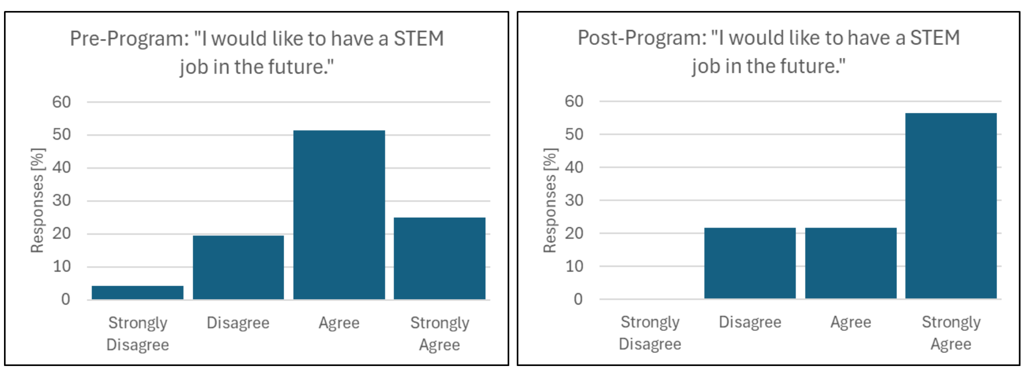
(a) (b)

Figure 4. (a) Pre-Program responses (n=72) and (b) Post-Program responses (n=23) to the survey question: "I enjoy learning new ideas about STEM".



(a) (b)

Figure 5. (a) Pre-Program responses (n=68) and (b) Post-Program responses (n=23) to the survey question: "I think of myself as a STEM person".



(a) (b)

Figure 6. (a) Pre-Program responses (n=72) and (b) Post-Program responses (n=23) to the survey question: "I would like to have a STEM job in the future".

This material is based upon work supported by the National Science Foundation under Grant No. 2148429.

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