Board 151: An After-school STEM Program with a Novel Equitable and Inclusive Structure (Work in Progress, Diversity)

Dr. Matthew Aldeman, Illinois State University

Matt Aldeman is an Associate Professor of Technology at Illinois State University, where he teaches in the Renewable Energy and Engineering Technology programs. Matt joined the Technology department faculty after working at the Illinois State University Center for Renewable Energy for over five years. Previously, he worked at General Electric as a wind site manager at the Grand Ridge and Rail Splitter wind projects. Matt's experience also includes service in the U.S. Navy as a nuclear propulsion officer and leader of the Reactor Electrical division on the aircraft carrier USS John C. Stennis. Matt is an honors graduate of the U.S. Naval Nuclear Power School and holds a B.S. in Mechanical Engineering from Northwestern University, a Master of Engineering Management from Old Dominion University, and a Ph.D. in Mechanical and Aerospace Engineering from the Illinois Institute of Technology.

Jeritt Williams, Illinois State University

Jeritt Williams is an assistant professor of Engineering Technology at Illinois State University, where he teaches applied industrial automation and robotics.

Allison Antink-Meyer, Illinois State University

Allison Antink-Meyer is a pre-college science and engineering educator at Illinois State University.

Dr. Jin Ho Jo

Dr. Jin Ho Jo is an Associate Professor of Technology at Illinois State University, teaching in the Renewable Energy program. Dr. Jo is the program coordinator and also leads the Sustainable Energy Research Group at ISU. Dr. Jo is an honors graduate of Pu

Maria Luisa Zamudio

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Abstract

An interdisciplinary team of faculty, staff, and students at Illinois State University is partnering with the Chicago Public Schools district (CPS) and non-profit Community-Based Organizations in four Chicago neighborhoods to create a new after-school STEM program known as SUPERCHARGE. Funded by NSF, the primary purpose of the project is to increase the number of students from underrepresented groups who pursue STEM fields at the postsecondary level. Faculty from STEM and STEM education program areas as well as the National Center for Urban Education at Illinois State University comprise the leadership team for the project. Guided by the National Research Council's STEM Learning Ecosystem Model, SUPERCHARGE will contribute to the disruption of inequities that hinder access to STEM career pipelines for participants by serving as a bridge between informal high school academic experiences, STEM-related higher education programs, and STEM-related career pathways. Research to determine the impact of the program on students' interest, understanding, and self-efficacy towards STEM careers, as well as teachers and undergraduate students' understanding of promoting change, will also be conducted. The Partnerships in Education and Resilience (PEAR) Common Instrument for students and teachers, and interviews with stakeholders are being used to support data gathering and program feedback. These data sources will be used for program assessment and future research.

Introduction

An interdisciplinary team of faculty, staff, and students at Illinois State University (ISU) is collaborating with Chicago Public Schools (CPS) and non-profit Community-Based Organizations (CBOs) in four Chicago neighborhoods to create a new after-school STEM program known as SUPERCHARGE: STEM-based University Pathway Encouraging Relationships with Chicago High schools in Automation, Robotics and Green Energy. Recently awarded funding by NSF, the central motivation for the program is to increase the number of students from underrepresented groups who choose to pursue STEM subjects at the postsecondary level. The SUPERCHARGE project will increase interest in, awareness of, and opportunities for postsecondary study in automation, robotics, and renewable energy among students from populations that are underrepresented in STEM fields. The activities and program structures within this project will present students and educators with opportunities to explore these cutting-edge technologies and learn critical design and problem-solving skills that are essential for the future workforce of the "Fourth Industrial Revolution" [1]. Other benefits of the program will include professional development (including Continuing Education Credits) for CPS teachers, training and outreach experiences for undergraduate students currently studying in STEM fields at Illinois State University, the creation of 32 innovative STEM activities per program year, and educational materials and equipment for the partnering high schools.

The four project goals are:

1. SUPERCHARGE Scholars (high school student participants) will increase their knowledge of STEM domains and careers; specifically, those related to renewable and sustainable energy systems, robotics, and technology. Simultaneously, they will increase their understanding of the secondary and post-secondary pathways that lead to attainment of STEM careers.
2. SUPERCHARGE Scholars will increase their interest toward STEM careers and will demonstrate improved self-efficacy for career-related skills and for attainment of STEM careers.
3. SUPERCHARGE Designers (undergraduate Technology-related majors at Illinois State University will increase their awareness of "societal and contextual factors [that] constrain the opportunities for students from underrepresented groups to develop identities as STEM learners and professionals, and to participate in activities that can stimulate those interests and identities" [2]
4. SUPERCHARGE Teachers (school-based CPS teachers in after-school programming) will increase their knowledge of STEM domains and careers and will improve their knowledge of resources for students who are interested in pathways to STEM careers.

Project Rationale

One of the biggest challenges for Latinx and Black families comes when children finish high school and parents must decide whether – or how – to send their children to college. For many parents from underrepresented groups, this is a major decision, given the fact that their children may fall in the category of low-income first-generation students, and in many cases the parents do not understand how to navigate the higher education system or seek financial assistance. This is especially true for parents who are not native English speakers, because it is a built-in disadvantage when it comes to guiding their children on the route to college [3,4].

When asked about the underlying reasons why Black and Hispanic people are underrepresented in STEM fields, those working in STEM often point to factors rooted in educational opportunities [5,6]. Some 52% of those with a STEM job say a major reason for the underrepresentation is that Black and Hispanic people are less likely to have access to quality education that prepares them for these fields. Forty five percent attribute disparities to not being encouraged to pursue STEM-related subjects at an early age [7]. Around a third of people working in STEM careers attribute underrepresentation to not believing in their own ability to succeed in these fields (34%), the lack of Black and Hispanic role models in these fields (32%), and discrimination in recruitment, hiring and promotions (32%) [7]. The SUPERCHARGE project's primary focus on STEM education attempts to addresses, at a state level, the acute lack of representation of low-income and Students of Color in STEM programs nationwide [8].

Project Organization

The SUPERCHARGE project is organized as a four-year program spanning from July 2022 to June 2026. The project is currently in the midst of Year 1 (July 2022 – June 2023), which is designated as a planning, development, and iterative feedback year. The informal learning activities that are developed by Illinois State University faculty and undergraduate STEM students in Year 1 will be implemented in the after-school program during Year 2 (2023-2024). Informal learning materials for Years 3 and 4 will be developed in Years 2 and 3, respectively.

The four partnering high schools are each unique, located in different communities within the city of Chicago. Some of the schools have existing STEM-related extracurricular activities, but some do not. Although each school and each community are unique, all four of the schools have higher percentages of low-income students than the statewide average, and all four of the schools have lower science proficiency ratings than the statewide average.

During Years 2, 3, and 4, the after-school program will be implemented with approximately 20 students from each partnering high school participating in the program. The student groups at each school will meet once per week for approximately 90 minutes at a time that is convenient for the group - typically after school. The program will be open to high school students in grades 10-12. Recruitment of student participants will be jointly led by the CPS high school teacher-mentors and by partners from the CBO in each community. The CBOs are well-positioned to assist with student recruitment and other program activities because they are established centers of social and academic outreach that already act as liaisons between families and the partner schools. Recruitment will prioritize inclusivity and will be based on an expressed interest by the student to participate in a college-connected STEM enrichment program. Although resources are not unlimited, it is not our intention for the program to be selective. The program enrollment cap at each school is not rigidly fixed at 20 but is instead based on a balancing of material resources, teacher-mentor oversight capacity, and physical space constraints. Due to graduation and other attrition, the group of students at each school will change from year to year, although students may also participate for consecutive years if desired. Thus, the informal learning experiences in each year of the program will be designed to stand independently. The student groups at each school will be led by two high school STEM teachers from the partner school, who will receive training, stipends, and professional development credits for their participation in the program. The teachers leading the program at each high school are not expected to be subject-matter experts, nor are they expected to "teach" the material. Rather, the teachers' role is to serve as advisor-mentors, while the informal learning activities are intended to stand alone as guided explorations. Research to determine the impact of the program on students' interest, understanding, and self-efficacy towards STEM careers, as well as teachers' and undergraduate students' understanding of promoting change, will also be conducted. The Partnerships in Education and Resilience (PEAR) Common Instrument for students and teachers, and interviews with stakeholders are being used to support data gathering and program feedback. These data sources will be used for program assessment and future research.

Year 1 (2022-2023) Content Material Preparation with Iterative Feedback
Faculty members will design informal hands-on STEM learning experiences with SUPERCHARGE Designers and with iterative feedback from CPS teachers.
Teacher Summer PD Workshop #1 (two days in Summer 2023): Introduction to the SUPERCHARGE project and the following year's learning material

Year 2 (2023-2024) Unifying Theme: Smart Monitoring of Climate and Weather
Final Culminating Project: Smart Weather Station
The main topics for the year are sustainability, climate, weather, and microcontroller (micro:bit) monitoring systems. As a final project, student Scholars will design and build their own weather station, which the Scholars will install at their school for data collection.
Unit 1 (September – October): Introduction to sustainability, climate, and weather
Unit 2 (November – January): Introduction to microcontroller (micro:bit) and programming
Unit 3 (February– March): Sensors and measurement: temperature, irradiance, wind speed, and humidity; Scholars mock-up weather station design and integrate sensors with microcontrollers
Unit 4 (April – May): Data management and display; user interface development; final weather station construction and design iteration
Student Summer Workshop #1 (three days in Summer 2024): ISU Team leads Scholars in applications and extensions of weather material using data collected by weather stations up to that point; field trip to STEM-related companies and/or STEM guest speakers
Teacher Summer PD Workshop #2 (two days in Summer 2024): Intro. to Year 3 material

Year 3 (2024-2025) Unifying Theme: Robotics and Solar Energy
Final Culminating Project: Solar Photovoltaic Robotic Tracking System
The main topics for the year are robotic control systems and solar energy. The end-of-year culminating project is the construction of a robotic solar tracking system. Students will use weather data to assess solar resources at their school and predict solar energy production.
Unit 1 (September – October): Solar energy and photovoltaics; solar resource assessment
Unit 2 (November – January): Discussion of Universal Systems Model; control systems and intermediate-level programming of microcontrollers (includes material refresher)
Unit 3 (February– March): Robotics and actuators; motion and making things move; solar tracking devices; control system design; assembly of desktop-sized solar tracking systems
Unit 4 (April – May): Assembly and programming of full-scale solar tracking system with one

full-size solar panel; creation of a monitoring and data logging system
Student Summer Workshop #2 (three days in Summer 2025): ISU Team leads Scholars in applications and extensions of solar energy topics; comparison of weather station data to solar system output; field trip to STEM-related companies and/or STEM guest speakers
Teacher Summer PD Workshop #3 (two days in Summer 2025): Intro. to Year 4 material

<u>Year 4 (2025-2026)</u> Unifying Theme: Sustainable Transportation and Electric Vehicles
Final Culminating Project: All-Terrain Electric Scooter
The main topics of the year are sustainable transportation and electric vehicles, particularly in the context of the urban communities where the Scholars live. As a final project, teams of Scholars at each high school will design and build two all-terrain electric scooters
Unit 1 (September – October): Sustainability and efficiency of transportation vehicles: planes, trains, automobiles and ships and potential advanced solutions like Hyperloop and flying cars
Unit 2 (November – January): Batteries and Battery Management Systems; battery charging
Unit 3 (February– March): Electric motors and motor control; construction of multiple mini desktop-sized electric vehicle "control modules"
Unit 4 (April – May): Scholars design, construct, and test two all-terrain electric scooters per high school. Scooters include microcontrollers to monitor speed and distance, control battery charging and discharging, and estimate range remaining.
Student Summer Workshop #3 (three days in Summer 2026): ISU Team leads Scholars in applications and extensions of electric vehicles including all-terrain electric scooters; testing all systems on scooters; field trip to STEM-related companies and/or STEM guest speakers

Conclusions

The team is currently more than halfway through the first year of the project. Many of the lessons learned to date involve planning, communication, and project management. Lessons learned to date include:

1. Creating a detailed and sequential plan of specific informal lesson activities took more time than expected. Despite having what the team initially thought was a reasonably detailed plan for the learning activities to be created in the first year, the project nevertheless felt very open-ended, vague, and slightly overwhelming for the first several months. This may have put the undergraduate SUPERCHARGE Designers in an uncomfortable – but perhaps beneficial in the long-term – position at the beginning of the project as they began to fill in the details with specific informal lesson activity topics. Faculty team members wanted to give the undergraduate Designers the freedom and flexibility to create activities around the topics that the undergraduate students thought were most relevant to the overarching themes of the project, but meanwhile, the undergraduate Designers were anxious to make sure their ideas did not conflict with what the faculty team had already planned. In the end, it took several weeks of conversations between undergraduate Designers and the faculty team to create a more detailed, week-by-week schedule of informal activity topics. In the coming years, project faculty will think carefully about balancing the benefits of posing an open-ended challenge to the undergraduate Designers, against the time and efficiency advantages of providing a more detailed topical outline at the beginning of the academic year.
2. Project nomenclature was initially a barrier to effective team communication. The project activities were initially difficult to describe – even among team members – because the team

had not yet decided on a standard nomenclature. Once the team realized that this was a problem, portions of several meetings were spent deciding on a label for each section of the overall informal curriculum. The team intentionally avoided the term “weekly” and more formal terms like “lessons” and “objectives” because we do not want to assume the timing of when the high school student meetings will take place, and we do not want the materials to have the feel of a formal classroom environment. In the end, each informal lesson is called an “activity”, there are 3-5 activities in one “module”, and there are four modules in one “unit”. Each module and unit have a coherent and unifying theme. There are two units per year: Unit 1 in the fall semester, and Unit 2 in the spring semester.

3. The preferred method of communication varied among team members. The team eventually settled on using two primary modes of communication: email and the GroupMe app. While the faculty members are more comfortable using email than GroupMe, the faculty members also use the GroupMe chat for more routine and less detailed communication.
4. Progress tracking of curriculum development required a dedicated tool. With 32 learning activities in various stages of development, it became tedious and overwhelming to keep track of the status of each activity. To alleviate confusion, we created a detailed spreadsheet – shared on Google Drive – to track the current development status of each activity. Among other details, the tracker lists the person responsible for each activity, the due date, the current status (a drop-down menu with the options “Assigned,” “Ready for review,” “Feedback given,” “Ready to publish,” and “Published”), and a space for comments.
5. Micro:bit is a capable, budget-friendly technology upon which to build the program. We spent several weeks at the beginning of the project discussing technology options. The strongest contenders were micro:bit and Arduino microcontrollers. We selected micro:bit because of its budget-friendly price, easy integration with the MakeCode website, and the ability to code the device using pre-built blocks, Python, or Java. Although supply chain constraints initially caused anxiety over whether we would be able to procure enough of them, those issues have gradually subsided, and we have been able to purchase enough devices to give one micro:bit to each high school student in the program.
6. The online collaboration tool required deliberate standardization. Early in the project, team members gravitated to whichever platforms they were accustomed to using. This led to a splintering of project materials between Microsoft OneDrive, Microsoft OneNote, and Google Drive. After discussion, the team agreed to use OneDrive for project administration, budget, and organization purposes, while Google Drive is used for all curriculum development-related activities. Google Drive was selected as the tool for curriculum development in part because CPS is a Google district. This allows for convenient sharing of material between the ISU team and CPS teacher partners for feedback. In the future, the final version of the curriculum will be deployed on a website for implementation. We are considering the use of Google Sites for final deployment due to the convenience of embedding Google Drive documents into a Google Sites website. However, due to the constraints of Google Sites, we are also considering the development of our own website.

Despite these challenges, and despite being a truly interdisciplinary team of faculty, staff, and undergraduate students, the project team members work remarkably well together. Team members enjoy the collegial and friendly environment that permeates the team. This collegiality likely results from a recognition and appreciation of the fact that each team member brings a valuable and unique skill set to the project.

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