

## **A Model for Immersive STEM Education: Lessons from 10 Years of Cross-Sector Collaborations in Philadelphia**

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### **Abstract**

“When I grow up, I want to build things.” “When I grow up, I want to fly in space.” When do children's dreams fall away from youth and teens' aspirations and plans for their future? How do we support all children in pursuing those dreams, especially within STEM careers? The fact is that too many students in the U.S. are underprepared, underrepresented, and overlooked to meet the growing need for competent employees in STEM fields. Here, we present a case study of how an informal STEM education program in Philadelphia leverages cross-sector collaborations to provide high-quality, engaging learning experiences with students from historically underserved schools. University City Science Center’s FirstHand program serves middle and high school students through free, multi-week STEM programming. FirstHand fosters deep partnerships with schools and professionals from STEM companies to curate authentic, mentored learning experiences that are not possible in most Philadelphia classrooms. Through Firsthand, students gain a team of experts, including their teachers at both school and FirstHand, to support their exposure to, exploration of, and planning towards a STEM-focused future.

External evaluators have helped measure the program’s sustained success and understand the broader impact of FirstHand on participants and partners through program observation, pre- and post-program surveys, focus groups and more. In this article, we detail the collaborative model leveraged by FirstHand and suggest how that model can be implemented across different regions and content areas.

### ***The Issue: Systemic STEM Education Disparities***

Innovations in STEM have been and continue to be paramount to the United States’ global leadership and economic prosperity. Over the next decade, STEM occupations are projected to grow by 10.8%, compared to 2.3% growth in non-STEM occupations (BLS, 2023). Philadelphia’s rapidly growing life science workforce is desperate for qualified and engaged workers, yet many of the city’s residents have few pathways into the opportunities offered by the field.

Despite this growth, national and international assessments show students’ competencies to fill such roles are lacking. Recent data from the National Assessment of Education Progress (NAEP) highlights that only 22% of U.S. 12th graders scored proficient or higher in science. These scores

are even more stark for students of color living in low-income U.S. communities. Here in the School District of Philadelphia (SDP), only 23.3% of Black and Hispanic students scored proficient or advanced in the state science assessments, compared to 54.3% of their White peers (SDP, 2023).

***A Solution: Cross-Sector Collaborations Across Education Providers and the STEM Industry***

Out-of-school time (OST) and informal learning opportunities that supplement traditional classroom learning can begin to combat these disparities, and there is growing evidence that engaging with STEM content outside of school directly influences classroom competencies and broadens participation in STEM (Saw, 2020). We know that regional cross-sector partnerships are essential to adequately responding to the needs of all communities that engage with such programs (Rhodes, 2024). To create and sustain a STEM program like FirstHand, a coalition of informal education providers, private-sector companies, and Philadelphia schools is needed.

For 60 years, the West Philadelphia-based University City Science Center has been a leader and partner in innovation-driven regional economic development. Located at the heart of the uCity Square campus, home to over 200 businesses, the Science Center trains STEM entrepreneurs, supports the commercialization of new technology, cultivates STEM talent, and convenes innovators. Recognizing that joyful STEM learning may inspire more Philadelphia students to enter the booming life sciences landscape in Philadelphia, the Science Center launched FirstHand in 2014.

Designed to provide equitable, high-quality STEM experiences, FirstHand offers free, industry-relevant programming that supports classroom learning by introducing students who attend some of Philadelphia's most systematically under-resourced schools to STEM learning and career pathways. FirstHand serves as a bridge between Philadelphia middle and high school students, the formal classroom, and STEM industry professionals (Fig. 1). Celebrating ten years of programming in 2024, FirstHand has spent the last decade opening its doors to more students and honing the cross-sector partnerships that are vital to the program's success.



*Figure 1. FirstHand connects Philadelphia students to STEM professionals through cross-sector partnerships.*

FirstHand implements three programmatic elements to build students' scientific identities, interests, and knowledge: (1) hands-on, discovery-based STEM **experiences**, (2) **an immersive, place-based learning environment**, and (3) **industry-relevant mentoring**.

*The Experiences:* FirstHand offers a suite of free, industry-informed STEM curricula with no tests, grades, or homework through which students engage in the same hands-on tasks as professionals – for example, performing gel electrophoresis to visualize DNA. Middle school students participate as a school cohort and travel twice a week, during school hours, for ten weeks (20 hours) to the FirstHand lab with a school chaperone. High school students participate in 8-week (16-hour), targeted career-exposure programs called “Sprints” that are co-developed and co-delivered by STEM professionals, and students are paid \$15/hour achievement-based stipends. Cohort sizes for all programs are capped at 16 students, allowing for a low student-to-teacher ratio.

*The Place:* FirstHand is a place-based program that takes place at our “learning lab,” which mirrors a professional lab. Students are immersed in and share all aspects of the space with professionals – the elevators, hallways, lab supplies, etc.

*The Team of Mentors and Experts:* FirstHand sources and trains mentors from an array of STEM companies on the uCity Square campus to support students. To date, over 300 STEM professionals from 95 companies have volunteered a cumulative 1,560 hours. Mentor partners work with the FirstHand team to inform curriculum and provide direct student mentorship, with the shared goal that students understand the day-to-day work of Philadelphia STEM professionals. Middle school cohorts engage with their mentors three times across a 10-week curriculum – first, through activities in the mentors' workspaces, then working together to brainstorm their final project, and finally, at the final showcase where the students present to their mentors, families, and school communities. The success of this multi-touchpoint model in middle school programming led to the genesis of the high school Sprints, where mentors, ready to take on more, help co-create *and* co-facilitate curriculum alongside FirstHand geared for older students. Building on this work, those same mentors can host alumni as interns.

### ***Measuring Effectiveness***

Does FirstHand work? Yes. Nearly 30% of our more than 2,500 participants have come back for at least one additional FirstHand program, and we boast an average 87% attendance rate. FirstHand's external evaluations have been part of the program since its inception. Pre- and post-program surveys capture students' sense of belonging in science, scientific self-efficacy (i.e., a person's belief in their capacity to accomplish a goal), and perceived importance of science in their lives. Two years ago, FirstHand adopted a rigorous study with evaluation firm AnLar, which employs a 5-year randomized-controlled trial (RCT) to understand how participating in Firsthand impacts students' beliefs, feelings of belonging in science, and achievement in science.

We also collect formative data to inform continuous program improvement. Each session is scored using the STEM Program Quality Assessment (PQA), a reliable and valid observational tool that measures the qualities of the program environment and interactions. STEM-PQA ratings

have overwhelmingly shown that FirstHand is a well-rounded, high-quality program that provides a supportive, engaging environment and effective interactions that are likely to support students' emotional and academic well-being. The STEM-PQA ratings combined with student testimonials about their experiences show that FirstHand *is* achieving success. We view student testimonials as one of the most telling measures of effectiveness, and this one from a seventh-grade student from Alain Locke School speaks for itself: “FirstHand is a really refreshing environment to experience. Even if you're not interested in science, you'll have some type of curiosity after you walk out of here. After every lesson, it makes you want to go to YouTube. It's a good place to step outside of your comfort zone, and it's a safe, sacred place kind of...where you can get away from school; it is kind of like school, but it's not.”

### ***Why FirstHand Stands Apart***

FirstHand operates within the research that science knowledge is developed through active learning, observations, and interactions (Linn and Eylon, 2011; Smith and Neale, 1989). High-quality OST programs position STEM as socially, culturally, and personally relevant and allow students to lead and connect learning across the classroom, home, and other settings by leveraging community partnerships (NRC, 2015.) FirstHand stands apart as strong, mutually-beneficial partnerships with schools and the private sector are the lynchpin for program success – leading to a fuller, more immersive experience for the students.

FirstHand challenges the idea of what can and should happen during school hours by asking, “What if instead of watching science videos at school, students commuted to a professional workplace and used the same tools and experiments as the scientists down the hall?” Many Philadelphia schools are overcrowded with limited physical resources to conduct lab experiments, and the staff craves a sustained way to share hands-on learning with students. FirstHand brings resources, mentors, and the opportunity for science teachers to consider how they can bring hands-on learning to more students. Schools ease the recruitment burden that often falls on OST programs and, by attending during the school day, support students who are often excluded from afterschool offerings. Recently, Dr. Spencer, Principal at John F. McCloskey School, shared, “FirstHand is a window to the world for my students. The program provides exposure to something beyond their norm, encouraging the children to wonder about what could be.”

STEM companies and professionals bring authenticity to student learning, while FirstHand affords professionals opportunities to engage with students in a collaborative way that has a low barrier to entry, especially given that mentors often don't need to leave their building. We boast a 95% mentor retention rate, highlighting that our approach to partnering with companies is working. Recently, a mentor shared, “It feels great to be able to share my experiences with the students in hopes that they can make better decisions in their lives. Also, it helps me to hone my mentorship skills so that I can be better for each new round of students, and sharing information about new projects and technologies helps me feel more grateful for how far I've come in my own career.”

### ***Discussion and Recommendations***

FirstHand is a blueprint for cross-sector collaborations that prepare students to thrive in local industries. We share this as we are currently supporting the creation of a similar program in a southern U.S. city. While it may look different based on need, resources, and partnerships, this coalition-building model is customizable to regional needs and calls on all entities that have a stake in growing and inspiring local talent to participate for maximum outcomes. If the primary industry in a region is agriculture, for example, then professionals in ag-related fields should guide the program development just as much as the leading organization and the local education stakeholders do.

Our team has learned countless lessons over the last ten years on how to run a program, but if we had to pick three recommendations to share here, they would be:

- 1) Approach partnerships with intention, patience, and humility. Strong, trusting partnerships do not happen overnight, and value-adds from all partners are essential to long-term success. Note that not everyone will be a good partner for your intervention, and that's okay.
- 2) Success should be broadly defined. If you are a STEM education program then, of course, you want students to develop a life-long love for STEM learning that results in a rewarded career. However, success also looks like a student recognizing that science class can be interesting or meeting a scientist who looks like them.
- 3) Identify your program's unique strengths and rely on partnerships to fill gaps. FirstHand offers resources and mentorship that few schools have the capacity to provide while relying on school partners to recruit the students who will most benefit from FirstHand. Similarly, industry professionals bring a wealth of relevant learning experiences to participants that even the best educator cannot impart to students.

### ***Conclusion***

FirstHand, a decade later, looks quite different. Yet, the core of the program remains strong. We are still a proud neighbor of West Philadelphia and welcome students to our space during the school day while remaining joyfully reliant on and committed to strong, responsive partnerships with Philadelphia schools and STEM companies. Looking ahead to the next ten years, the Science Center's FirstHand program will continue to lean on our partners to maintain relevant offerings that benefit Philadelphia community members, businesses, and students.

Hilary Rhodes from the Philadelphia-based William Penn Foundation imparted some closing wisdom in her recent 2024 report, "What We're Learning From Our Stakeholders: Learning Into Community Voice." Coordination among service providers is limited, and that results in community members missing out on valuable resources. In other words, when we're talking about supporting our community, we cannot underestimate the power of strong collaborations.

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