STEM Smart Brief

STEM Smart: Lessons Learned From Successful Schools






Connecting Informal and Formal STEM Education

THE PROBLEM

When it comes to STEM education, the nation's K–12 public schools cannot do it all. The nature of 21st century proficiency in science, technology, engineering, and mathematics is too complex for any single institution. The good news is that schools do not have to do it alone. Museums, zoos, nature centers, aquariums, and planetariums are among the several thousand informal science institutions in the United States that regularly engage young people in observing, learning, and using STEM knowledge and skills. Providing a richness of resources unavailable in any classroom, informal science institutions across the country have developed exemplary partnerships with public schools—and have room for more.

Partnership programs cover a variety of topics and types, from curriculum-related experiments during field trips to intensive after-school math lessons to teaching teachers about the latest developments in environmental science.

Striking Statistics: Formal and Informal STEM Collaborations

* Almost 75% of science-rich cultural institutions in the United States have programs specifically designed for school audiences.[1] These include half-day workshops, year-long programs, materials, and curriculum support, as well as one-day field trips.
* Extrapolated figures estimate that informal science institutions serve more than 60% of U.S. schools, directly or indirectly impacting 9,000 districts, 2 million teachers, and 36 million students.[2]
* Almost half (44%) of the schools using informal science institution programs have a proportionally large population of traditionally underserved students compared with other schools in their region.[3]
* Informal science programs generally have excess capacity. Survey respondents indicated that 53% of the programs could handle a greater number of participants than they currently serve, while only 24 percent of the programs have to turn people away.[4]

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KEY RESEARCH

A growing consensus among researchers is the need to develop more collaborations between public schools and informal science institutions, including museums, youth programs, and libraries. But more essential than number is quality. The key is to be more strategic with resources, building on the strengths of particular institutions to help make science learning more compelling for K–12 students.

"There can be a really nice complementary relationship between schools and these informal environments," says Heidi A. Schweingruber, co-author of *Surrounded by Science: Learning Science in Informal Environments*. "As we talk about improving science education, we don't want to overlook the important role that these informal settings can play…. [They] can be part of a whole system that supports science learning."[5]

This same comprehensive study funded by the National Science Foundation identified "substantial evidence" that there are a large number and wide range of formal-informal science education collaborations. A small number of exemplary programs have collected outcomes data, showing that such collaborations yield numerous positive effects. Among the educational goals they can meet: advancing students' conceptual understanding in science, improving students' school achievement and attainment, strengthening students' positive dispositions towards science, advancing teachers' conceptual understanding in science, and helping teachers to integrate the inquiry process and new materials to their classrooms.

The CAISE study documented effective collaborations in five general areas:

- *Supplementary classroom enrichment*, which builds on goals for classroom STEM study, such as field trips, demonstrations, or after-school science programs
- *Integrated classroom resources*, which informal institutions develop to become part of the core academic curriculum, including materials, activities, regular field trips, and field research projects
- *Sustained student learning communities*, which work directly with K–12 students in after-school, weekend, or summer programs—separate from their school's core curriculum—to grow skills, knowledge, and potential career pathways
- *Sustained teacher learning communities*, which use resources of the science institution to provide ongoing professional development for teachers on science content and/or pedagogies
- *District infrastructure development*, which is a collaboration between institutions and districts as part of long-term improvement strategies, including novice teacher training, ongoing professional development, and curriculum planning projects.

In spite of these successes, there are challenges in sustaining these collaborations. Many programs come and go after a few years due to funding constraints or leadership changes, and regardless of results.

Supplementary Classroom Enrichment

Most often in the form of field trips, supplementary classroom enrichment is probably the most common type of formal-informal science education collaboration. Educators interested in field-trip design can find information in many places.[6] But as every teacher and parent chaperone knows, and as research shows, field trips yield mixed results regarding their short-term impact on student knowledge, interest, and attitudes.[7]

Less common, though potentially more effective, are supplemental programs where formal and informal educators co-design activities that they hope will connect with and enrich their classroom studies. They have sequenced curriculum units, like school classes, but students do the work in low-stakes, multi-modal, hands-on approaches.

Example: Minds-on-Math, at Sci-Port in Shreveport, Louisiana[8]

Sci-Port, a science center in Shreveport, developed this small K–8 after-school program in partnership with Caddo Parish Schools to help students struggling with math concepts. Bringing together elementary and middle school students with museum educators and district teachers twice a week for seven weeks, Minds-on-Math has documented statistically significant improvements in state math scores. Each consecutive session reviews concepts from the previous session before introducing new content.

The program, run with funds from the Louisiana Department of Education, first gives diagnostic tests similar to Louisiana's state achievement tests to all participants, and then places students into groups of 10, based on the areas that need remediation. The advantage over traditional school-based remediation is the use of Sci-Port's exhibits, including tactile, 3-D, and life-sized teaching tools to guide math exploration. For example, in "Bed of Nails," students learn about inverse proportionality as they discover that the greater the area over which their weight is spread, the less pressure is exerted.

Family nights allow parents to meet with the instructors and siblings to explore the museum. All students receive a year-long Sci-Port Family Membership.

Integrated Classroom Resources

These are semester- or year-long programs that serve as the centerpiece of a classroom's science curriculum but blend informal and formal settings, resources, and pedagogies. The programs typically are full service, combining site-based programs for students, classroom resources, and teacher professional development.

Example: Urban Advantage, New York City [9]

Numerous science institutions collaborated with New York City's Department of Education in the early 2000s to address a severe shortage of qualified science teachers and a new requirement for all 8th graders to complete a long-term scientific investigation. The result was Urban Advantage, launched in 2004 by the American Museum of Natural History in collaboration with the Brooklyn Botanic Garden, the Staten Island Zoo, the New York Aquarium, and four other informal science institutions in the city.

The standards-based partnership aims to improve middle school students' understanding of scientific inquiry by teaching them the steps of the scientific method, and then supporting them in carrying out their own experiments, field studies, design projects, or secondary research.

The program also acknowledges the all-too-common irony that many young people who live near New York's great science institutions never visit them. In addition to participating in school field trips and workshops, students get vouchers for free family visits so they can return multiple times to the institution of their choice to collect data for their 8th-grade "exit project."

By 2010, Urban Advantage had grown from 5,000 students to 37,000 students, representing more than one-third of all middle schools in the city. Family resources are available in the nine different languages spoken in participating schools.

Early evaluation results showed a statistically significant impact on student achievement on the state intermediate level science exam. Moreover, 80% of participating teachers reported enhanced science content knowledge, while similar proportions of teachers reported improved understanding of scientific investigation, inquiry techniques, and secondary research projects.

Working with the NYCDOE, Urban Advantage also developed a set of guidelines to help students create their exit projects and an assessment rubric that teachers use citywide. Exit project examples presented at the UA Science Expo 2011 included the effect of location on water quality at Brooklyn beaches, the effect of different colors of light on sunflower plant growth, and the effect of exercise on memory.

Boston, Denver, and Miami recently have launched similar programs.

Sustained Student Learning Communities

These programs provide sustained, multi-year science learning for students spanning all grade levels. Although they have different levels of direct connection to a school's curriculum, they each provide a social learning space in which students can build their science capacities, understandings, commitments, and identities. Schools do not generally play a strong role in design or implementation, but they provide space, recruit participants, and communicate with parents.

Example: Science Club for Girls, Cambridge, Massachusetts [10]

Now in its 17th year, the award-winning Science Club for Girls (SCFG) was founded by Cambridge parents who were concerned about the lack of gender equity in math, science, and technology courses and careers. Clubs in Cambridge and several other Eastern Massachusetts communities bring together girls in grades K–7 in free after-school or weekend clubs, vacation-week science explorations, and half-day community science fairs. They also team up with professionals in the field who serve as their mentors. Adolescents in grades 8–12 can become junior mentors while doing the Career Exploration, Leadership, and Life Skills program. Other choices include the rocket team, the media team, the study of zebra fish, and the science of health, hunger, and food.

The main mission of the clubs is to increase self-confidence and literacy in STEM of K–12 girls belonging to groups that are underrepresented in these fields. Each semester is focused on a different STEM field, including biology, chemistry, engineering, environmental science, physics, and more. Each year, approximately 800 to 1,000 students participate. SCFG has documented changes in girls' attitudes towards science and science careers.

Sustained Teacher Learning Communities

These are multi-week professional development programs co-designed by schools and informal science institutions to improve the effectiveness of teacher classroom practices. Equally important is the development or strengthening of teachers' identities as capable and committed STEM teacher leaders. Programs address different combinations of conceptual understanding, classroom strategies, and STEM lessons/activities. They are not tied to the use of an informal setting or to specific mandated curricula, but rather to each individual teacher's own capacities and needs.

Example: Da Vinci Science and Discovery Center, Allentown, Pennsylvania [11]

The Da Vinci Teacher Leader Institute is a partnership to increase teachers' content knowledge, ability to use scientific inquiry in the classroom, and leadership activities, with the ultimate goal of increasing student science achievement. The project, funded through a U.S. Department of Education Math Science Partnership, has shown positive impacts in all of these areas. It is a collaborative effort of the Allentown School District, Cedar Crest College, and the Da Vinci Science Center. Teachers from several other regional districts have also been involved.

The project is organized around collegial networks. Da Vinci Fellows participate in content training at the science center, and then provide ongoing professional development to their colleagues, who become Da Vinci Peers at their various school sites. Since 2004, the project has served more than 300 teachers.

Each year, Fellows participate in 85 hours of professional development workshops, held primarily during an intensive two-week summer institute. The subject changes each year and includes physical science, life science, or Earth science.

District Infrastructure Development

These are joint district-informal efforts to address infrastructural challenges of local school systems. Building district capacity to design and lead inquiry-based professional development, or training and supporting lead teachers, is one example. Additionally, some science-rich cultural institutions participate in district- or state-wide standards or assessment committees.

Example: Leadership and Assistance for Science Education Reform (LASER), Seattle, Washington [12]

For nearly a decade, the Pacific Science Center (PSC) has demonstrated that informal education institutions can play key roles in K–12 statewide science education reform. Through its Leadership and Assistance for Science Education Reform (LASER) program, the PSC has helped to create 10 LASER Alliances that have provided professional development to about 20,000 teachers.

PSC staff have vetted new science curricula and developed science education materials for use across the state. Evaluation of state test scores has shown that student gains correlated with teacher participation in LASER.

LASER is one of eight regional sites across the country that has disseminated and implemented the adoption of NSF funded inquiry-based science curriculum materials.

LASER's teacher workshops stress (1) the content in the elementary curriculum, (2) inquiry-based teaching strategies, (3) the adoption and incorporation of NSF-funded curriculum materials into the classroom, and (4) how to integrate the science curriculum with other subject matter into the elementary classroom.

External evaluation of LASER has focused on teacher professional development, teacher classroom practice, and the relationship of these to student academic performance. Findings from the 2007–2008 school year evaluation studies suggested that students with the highest gains were instructed by teachers with a minimum of 18 hours of professional development. Furthermore, student gains were also more closely associated with those teachers who participated in professional learning communities and took time during the day to work on professional development.

RECOMMENDATIONS

As the CAISE report bluntly states, "The walls between formal and informal learning professional fields are only beginning to crumble. There is too little transfer of practice, learning, and community."

To make programs more effective and develop more effective programs, many things can be done despite the age-old funding dilemma:

- Expanding professional development for informal educators who work with formal audiences, specifically to address the nature of work with schools and teachers, including theories of learning, program design and evaluation, and assessment policies
- Expanding more teacher preparation programs to include introductions to informal learning institutions, resources, pedagogies, and people
- Expanding and testing program integration models, such as the co-development of K–12 science curricula and activities, or the investigation of how after-school settings can serve as professional development sites.

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[1] Bevan, B. et al. (2010.) *Making science matter: Collaborations between informal science education organizations and schools*. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE)—*citing a* recent study (Phillips, Finkelstein, & Weaver-Frerichs, 2007), which appears to cite The Center for Informal Learning and Schools. (2004.) *ISIs and Schools: A Landscape Study: Results from a National Survey of Informal Learning Institutions and Science Education*, Executive Summary. http://cils.exploratorium.edu/cils/page.php?ID=134

The survey was mailed to over 2,500 institutions; 475 informal science institutions completed and returned the survey. The response rate was 20 percent.

[2] The Center for Informal Learning and Schools. (2004.) *ISIs and Schools: A Landscape Study: Results from a National Survey of Informal Learning Institutions and Science Education*, Executive Summary. http://cils.exploratorium.edu/cils/page.php?ID=134

Estimates based on above numbers and several assumptions.

[3] Ibid.

[4] Ibid.

[5] "Sounds of Science from The National Academies," podcast interview with Heidi A. Schweingruber, Deputy Director, Board on Science Education,The National Research Council of The National Academies, and co-author of *Surrounded by Science: Learning Science in Informal Environments*. Podcast available at http://www.nap.edu/audioplayer.php?record_id=12614&n=0

[6] National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits.* Washington, DC: The National Academy Press.

[7] Fenichel, M. & Schweingruber, H.A. (2010). *Surrounded by science: Learning science in informal environments*. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, D.C. The National Academies Press.

[8] http://www.sciport.org/

[9] http://www.urbanadvantagenyc.org/

[10] http://www.scienceclubforgirls.org/

[11] http://www.davincisciencecenter.org/

[12] http://www.wastatelaser.org/

Community for Advancing Discovery Research in Education

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