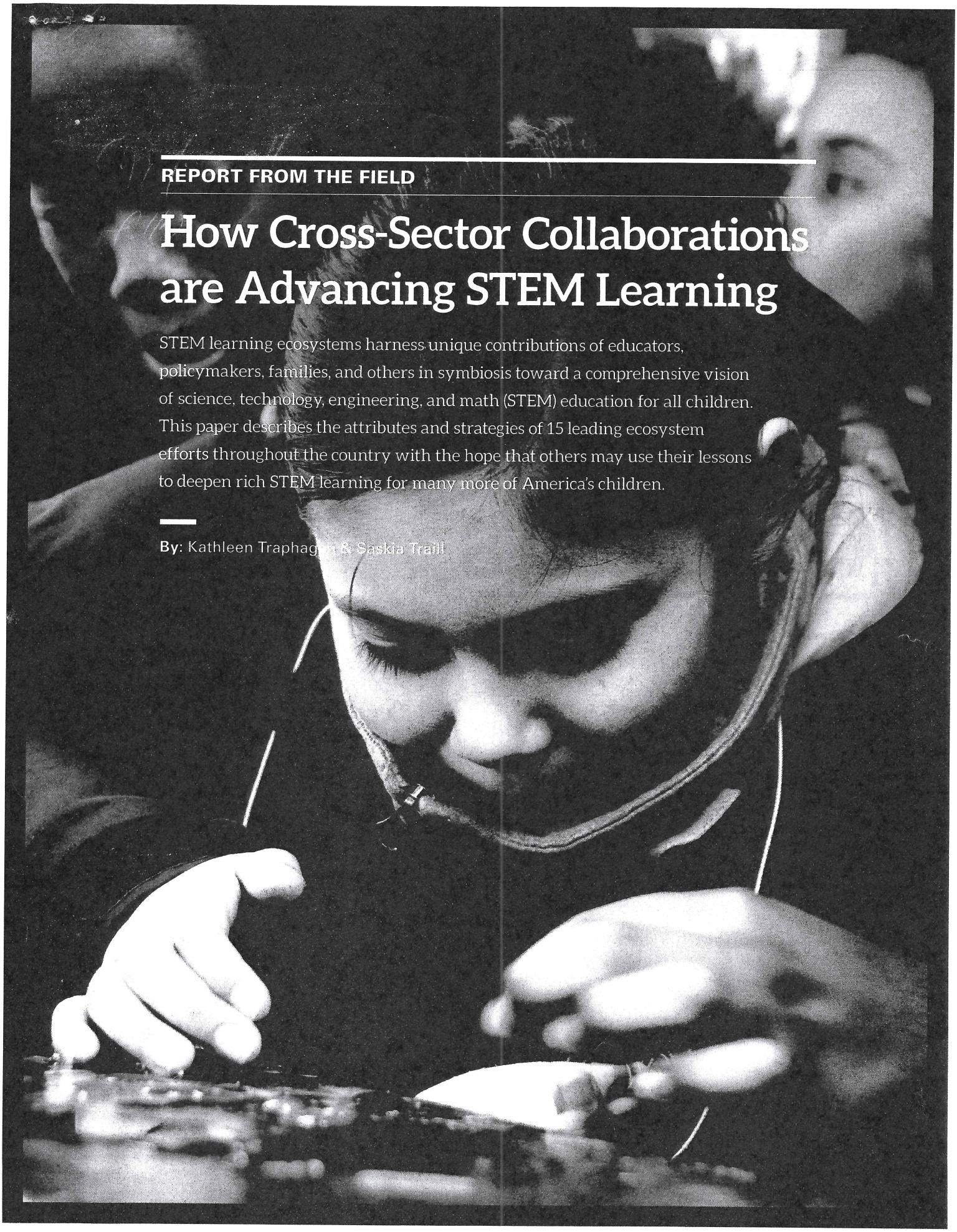

REPORT FROM THE FIELD

How Cross-Sector Collaborations are Advancing STEM Learning

STEM learning ecosystems harness unique contributions of educators, policymakers, families, and others in symbiosis toward a comprehensive vision of science, technology, engineering, and math (STEM) education for all children. This paper describes the attributes and strategies of 15 leading ecosystem efforts throughout the country with the hope that others may use their lessons to deepen rich STEM learning for many more of America's children.

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Table of Contents

Introduction

Substantial energy is now focused on improving science, technology, engineering and math (STEM) education in the United States. New data continue to justify the attention and highlight the complexities of the challenge: another round of middling PISA results for American students released in 2013; persistent under-representation of women and people of color in the STEM fields; continuing difficulties in sustaining young people's interest in STEM; and the startlingly poor showing of American adults on a recent international assessment of literacy and numeracy skills.[1]

Bolstering the STEM workforce is not the only reason to concern ourselves with these issues. Exposure to high-quality STEM experiences can inspire wonder and curiosity in students about the natural and human-constructed worlds and motivate them to want to learn more. Study of the STEM disciplines can foster students' ability to think critically about issues in a world that is now dominated by science and technology. Successful STEM learning develops in young people the ability to make rational decisions for themselves, their families and their communities.

Promising reforms are knocking on the door of the K-12 STEM classroom, including the Common Core and Next Generation Science Standards, both focused on deep conceptual understanding and expert application of knowledge and skills. High-profile efforts to better recruit, prepare and support STEM teachers as well as create specialized STEM schools are also driving reform in how STEM is taught in school.[2] Other efforts aimed at improving K-12 education overall are closely aligned to teaching and learning in the STEM disciplines, including competency-based education and the call for educators to explicitly focus on "deeper learning" skills young people need to live and work in today's global society – critical thinking, perseverance, problem-solving, teamwork and the capacity to pursue learning throughout life.[3]

Outside the school walls, STEM learning is everywhere. More than 90 million people visit science museums and centers every year to experience hands-on STEM learning.[4] Efforts by after-school and summer providers to integrate high-quality STEM learning experiences into their programming align well with the field's sharpening focus on active, relevant learning girded by positive relationships among children and adults. Portable digital devices have catalyzed thousands of creative opportunities for learning to happen anytime, anywhere, in ways that are both individualized and instantly connected to a worldwide community.[5] Media and online outreach aims to educate parents about the importance of STEM learning and the availability of local activities for young people.[6]

Bolstered by the National Research Council's Surrounded by Science report and Center for Advancement of Informal Science Education (CAISE) research, as well as other studies pointing to the value of intentionally connecting learning environments, many cross-sector efforts have

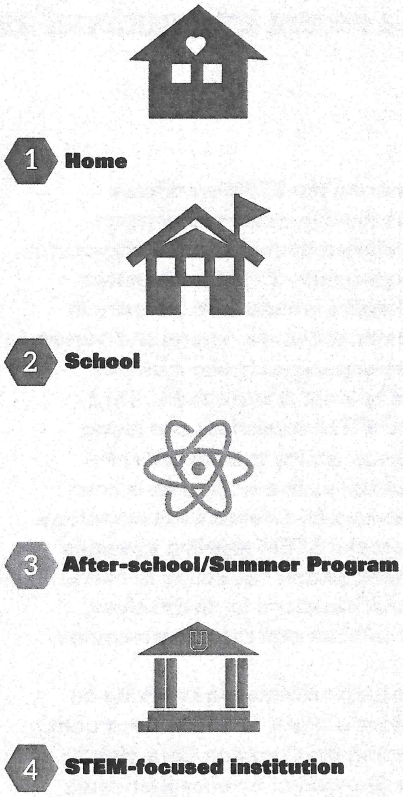
emerged (NRC, 2010, Bevan, 2010).[7] Schools are contracting with youth organizations to lead STEM-focused activities after school. Science centers and museums are increasingly offering training to schoolteachers, hosting student field trips and providing vouchers for family visits. These cross-sector partnerships are encouraging, but mostly limited in scope. Their arrangements tend to be binary and transactional, rather than holistic. For example, a science center trains teachers, but not after-school educators. A community-based organization leads the after-school program, but neither the content nor approach is connected to the school's STEM curricula. Efforts focus on one age group – for example, middle school students – and do not build on experiences the children might have had before or inform those that will come after. Even rarer are effective family involvement strategies that offer tailored support over time as children grow and their interests and skills mature. In most communities, the cultural, logistical, financial and philosophical barriers that divide educators and leaders from different STEM learning settings remain largely in place.

In this paper, we examine an approach to STEM learning that may eventually overcome those barriers: the STEM learning ecosystem. Over the past few years, many different thought leaders – practitioners, researchers, policymakers, funders and others – have been engaged in conversations about defining a broad and inclusive vision of STEM learning that puts the child at the center of the enterprise (Friedman, 2013).[8] The ecosystem metaphor, while not perfect, captures key concepts of this broader vision: diverse, individual actors interconnected in symbiotic relationships that are adaptive and evolve over time.

STEM Learning Ecosystems – A Definition

A STEM learning ecosystem encompasses schools, community settings such as after-school and summer programs, science centers and museums, and informal experiences at home and in a variety of environments that together constitute a rich array of learning opportunities for young people. A learning ecosystem harnesses the unique contributions of all these different settings in symbiosis to deliver STEM learning for all children. Designed pathways enable young people to become engaged, knowledgeable and skilled in the STEM disciplines as they progress through childhood into adolescence and early adulthood.

Stakeholders in a STEM ecosystem develop a shared vision and assess the strengths and gaps of their efforts to reach that vision. Educators, whether K-12 teachers, after-school staff, or experts in informal STEM institutions, work across settings to increase their individual efficacy, while at the same time deepening understanding and respect of the role of educators in other settings. Effective practices are shared across settings, while innovative program models are flexibly adapted to solve entrenched STEM learning challenges. Cross-sector professional development opportunities and communities of practice improve pedagogy and build knowledge among educators across settings.



Approaching STEM learning with an ecosystem mindset could also play a key role in helping communities meet the vision of the Common Core state standards in mathematics, the Next Generation Science Standards, and the broader Framework for K-12 Science Education. As a 2010 report by the CAISE asserted, the Framework's vision of scientific literacy "involves a rich array of conceptual understanding, ways of thinking, capacities to use scientific knowledge for personal and social purposes, and an understanding of the meaning and relevance of science to everyday life" that no single sector can provide by itself.[12] In a STEM learning ecosystem, young people's experiences could connect horizontally across formal and informal settings at each age, and scaffold vertically as they build on each other to become deeper and more complex over time.

Approach of this Study

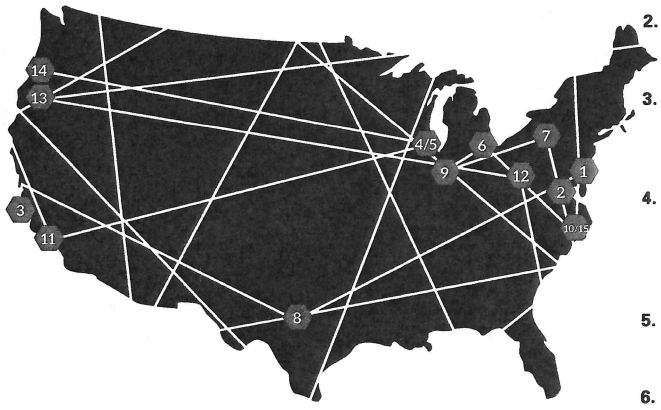
Commissioned by the Noyce Foundation, this paper sets out to provide shape and definition to the emerging concept of STEM learning ecosystems by identifying burgeoning efforts in a range of places across the U.S. – urban, rural, suburban; resource-rich, resource-poor, and in-between. Not intended to be an exhaustive analysis of current efforts, the goal of this paper is to spark conversation, networking, and further research about learning ecosystems by a broad range of stakeholders in the STEM education sector.

Our data-gathering strategy was to access an ever-expanding web of thought leaders, policymakers, funders and practitioners from formal and informal STEM learning settings and ask them to recommend examples of cross-sector STEM learning collaborations. We talked to about three dozen people and narrowed our focus for this paper to 15 initiatives. None of these initiatives constitutes the fully formed ideal described above nor encompasses the full ecosystem of STEM learning in their communities. However, each minimally includes a cross-sector collaboration among formal K-12 education, after-school or summer programs, and/or some type of science-expert organization. Within this group, we found significant differences in scale, vision, approach, and impact. Some are moving toward extensive multi-sector collaborations, while others are just beginning to envision what a more connected ecosystem might look like.

We did find many attributes and strategies in common, which we detail in forthcoming sections. We conclude by offering recommendations to spur further progress, exploration and study. An appendix provides contact information on each of the models studied.

A note on terminology: as we talked to leaders from many sectors to prepare this study, we encountered significant differences in terminology. For this paper, we use "formal" to mean schools and school systems and "teachers" to mean certified K-12 schoolteachers. "Informal" refers to programs offered after-school or during the summer, by community-based youth providers, schools, or by science museums and centers, also referred to as "science-expert institutions." "Educators" is the broad term we use to reference both classroom teachers and staff leading these programs.

Emerging STEM Learning Ecosystems Profiled in this Report



1. **AFTERZONE SUMMER SCHOLARS**
   Providence, RI
2. **BOSTON SUMMER LEARNING PROJECT**
   Boston, MA
3. **CALIFORNIA ACADEMY OF SCIENCES, SCIENCE ACTION CLUBS**
   San Francisco, CA
4. **CENTER FOR THE ADVANCEMENT OF SCIENCE EDUCATION, MUSEUM OF SCIENCE AND INDUSTRY**
   Chicago IL
5. **CHICAGO PRE-COLLEGE SCIENCE AND ENGINEERING PROGRAM**
   Chicago, IL
6. **DETROIT AREA PRE-COLLEGE SCIENCE AND ENGINEERING PROGRAM**
   Detroit, MI
7. **EXPANDED LEARNING NETWORK OF THE SOUTHERN TIER**
   Corning, NY
8. **GIRLSTART**
   Central Texas
9. **INDIANA AFTERSCHOOL STEM INITIATIVE**
   Indiana
10. **NEW YORK CITY STEM EDUCATORS ACADEMY**
    New York, NY
11. **ORANGE COUNTY STEM INITIATIVE**
    Orange County, CA
12. **SHINE (SCHOOLS AND HOMES IN EDUCATION) AFTERSCHOOL PROGRAM**
    Carbon and Schuylkill counties, PA
13. **SMILE (SCIENCE AND MATH INVESTIGATIVE LEARNING EXPERIENCES)**
    Oregon
14. **SYNERGIES**
    Portland, Oregon
15. **URBAN ADVANTAGE**
    New York, NY

STEM learning ecosystems have the potential to:

1. Enable children's understanding of cross-cutting concepts to unfold and deepen in intentionally connected ways over time and across settings
2. Build children's scientific practice skills and knowledge through multiple exposures and experiences, including those in which children have the freedom to make and learn from mistakes as part of scientific tinkering and experimentation
3. Spark and nurture children's interest in and enthusiasm for STEM over time, by not only bringing science lessons to life in STEM-rich learning environments like museum exhibits, biology labs, recording studios, and marine research vessels, but also exposing children to STEM professionals and a variety of STEM career options
4. Ensure that children build complex skills, including how to exercise their own agency, solve real-world problems, build relationships with adults and peers, and test out their own leadership and teamwork capabilities as they experience STEM learning connected across different environments
5. Intentionally support those youth historically under-represented in STEM including girls, linguistic and racial minorities, and economically disadvantaged young people, to foster diverse and inter-connected STEM learning experiences
6. Increase understanding and build capacity among parents and caregivers to support their children's learning by ensuring they receive consistent messaging, guidance and resources from multiple, diverse learning settings
7. Implement creative and diverse methods of assessment, equipping young people with certifications, badges, portfolios or other proof points demonstrating mastery of skills and knowledge that are understood and respected in diverse environments

This ecosystem approach is bolstered by two recent studies of mathematically talented students that found those "who had greater exposure to accelerated, enriched, and individualized STEM learning opportunities achieved more significant STEM accomplishments later in life than their matched counterparts." An analysis of this research noted that an important implication of the findings is the "need to ensure that students have access to a wide spectrum of enriching and accelerated learning opportunities, and, in particular, that opportunities include those that are individualized."[10]

STEM learning ecosystems could also help strategically target financial and other resources where they are most needed, a critically important task in this era of record-setting economic inequality. A new study has found that by age 12, disadvantaged children have received about 6,000 fewer hours of learning time than their more affluent peers, and their families have been outspent by about $90,000 on learning and enrichment activities by more prosperous families.[11] Without access to enriching informal learning environments, children have fewer chances of finding that spark that will ignite their interest and ability to persevere in STEM.