The Case for Investing in Out-of-School Learning as a Core Strategy in Improving Science, Technology, Engineering, and Mathematics (STEM) Education

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Introduction

Our complex and changing world demands an adaptable workforce that is prepared to collaboratively reason through tough problems and come up with creative solutions to the challenges of tomorrow. STEM (science, technology, engineering, and math) educational opportunities cultivate students' curiosity and creativity while teaching them to work as a team, base their reasoning on evidence, and solve problems through experimentation. Our students must gain the critical thinking abilities and other transferrable skills offered by STEM to be prepared for the unknown challenges and opportunities of our future. As such, education in STEM must be elevated as a national priority by enacting education reforms, crafting policies to drive innovation, and adapting federal and state spending priorities.

Imagine STEM learning opportunities as a network of charging stations across the country. Kids power up their STEM skills by plugging into immersive activities extending beyond the standard school day, including hobby clubs, afterschool and summer programs, museums, parks, and online activities. In communities without enough of these outlets, children miss the chance to charge their learning outside of school. That lack of extra STEM practice can have a draining effect on the knowledge and skills they accrue at school.

Exposure to formal and informal learning in STEM subjects, beginning at an early age and continuing through high school, prepares our nation's students for the future ahead. Supporting quality science, technology, engineering, and mathematics education for all children and youth is therefore vital to our country's social and economic prosperity.

The purpose of this brief is to summarize what we know, what we are still striving to learn, and what we must do through public policy to achieve this goal.

Part One: What We Know about Science, Technology, Engineering, and Mathematics (STEM) Education in the United States

STEM education is closely linked with our nation's social and economic prosperity, and strong STEM skills are a central element of a well-rounded education. Why?

STEM Education Brings Prosperity, Preparedness and Opportunity

- One job in the high-tech sector leads to 4.3 jobs in local goods and services industries – which results in positive ripple effects across the entire economy.[1] Between 2014 and 2024, the number of STEM jobs will grow 17 percent, as compared to 12 percent for non-STEM jobs.
- At all levels of educational attainment, STEM job holders earn 11 percent higher wages compared to their same-degree counterparts in other jobs.[2]
- Almost all of the 30 fastest-growing occupations in the next decade will require at least some background in STEM.[3]

The problem

A survey of CEOs of major U.S. corporations in 2014 indicated that approximately 60 percent of job openings require basic STEM literacy, and 42 percent require advanced STEM skills; however, according to the Council on Foreign Relations, 60 percent of U.S. employers are having difficulties finding qualified workers to fill vacancies at their companies.[4] Furthermore:

- Twenty-eight percent say that at least half of their new entry-level hires lack basic STEM literacy;
- Sixty-two percent of CEOs report problems finding qualified applicants for jobs requiring advanced computer/IT knowledge;
- Forty-one percent report problems finding qualified applicants for jobs requiring advanced quantitative knowledge.

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[1] *Bay Area Council Economic Institute, December 2012.*

[2] Thomasian, John. (2011, December 1). Building a Science, Technology, Engineering, and Math Education Agenda: An Update of State Actions. *The National Governors Association Center for Best Practices.* Retrieved from http://www.nga.org/cms/home/nga-center-for-best-practices/center-publications/page-edu-publications/col2-content/main-content-list/building-a-science-technology-en.html

[3] *Business Center for a College- and Career-Ready America*

[4] Council on Foreign Relations Independent Task Force. (2012). U.S. Education Reform and National Security. *Council on Foreign Relations.* Retrieved from http://www.cfr.org/united-states/us-education-reform-national-security/p27618

Spotty access to resources like high-quality afterschool programs, science centers, libraries, and partners in STEM professions hinders the preparedness of our country's students to enter a world in need of STEM expertise. Equitable access to high-quality informal learning that engages young people in authentic STEM experiences is a critical piece of addressing these imbalances. Expanding the STEM learning ecosystem to include more learning environments for children will require crafting comprehensive public policies that recognize informal, afterschool and out-of-school programs in their roles as complements to formal education.

For example, African-American and Latino workers now represent 29 percent of the general workforce population (up from about 24 percent in 2001), but just 16 percent of the advanced manufacturing workforce, 15 percent of the computing workforce and 12 percent of the engineering workforce—all rates that have remained essentially flat for many years.[5] To fix this, we need to increase the number of strong STEM afterschool programs in communities that currently have too few, in order to ensure that all children, no matter where they live, have the opportunity to charge up their learning in STEM.

Minority students will be a growing part of the population—and of the potential talent pool. But too many of these minority students lack adequate preparation to major in and pursue careers in the STEM professions. African Americans, comprising just over 12 percent of the population, earn just 9 percent of all baccalaureate STEM degrees and make up only 3.9 percent of scientists and engineers in the workforce according to the National Science Foundation.

But, when we spark their interest early, students are more likely to continue on to study STEM subjects through high school, college and beyond. When we spark their interest early, we have the opportunity to reverse some of the problematic trends currently being seen, including that:

- In 2012, only 11 percent of African American and 14 percent of Latino fourth-graders reached proficiency in science. By the eighth grade, these numbers drop to eight percent for African Americans and 12 percent for Latinos. By the 12th grade, only four percent and eight percent, respectively, are proficient as measured by the National Assessment of Educational Progress.
- While progress has been made in some areas (such as biology and chemistry) toward equalizing the gender imbalance between men and women in STEM fields, women remain underrepresented in most STEM professions.[1] While women represent over 57 percent of college graduates, the number of women entering STEM fields is only 26 percent[1] and the number of women in fields such as engineering is even lower, at 22 percent (Hughes, 2013).

[5] http://www.usnews.com/news/stem-solutions/articles/2015/02/24/stem-workforce-no-more-diverse-than-14-years-ago

It's never too early to get children involved in STEM-themed education!

Girls must be involved in STEM subjects early in their K-12 education in order to increase the number of women in STEM fields.[1] Preparing women to pursue education in STEM fields will also increase the number of capable workers in STEM fields and positively contribute to the nation's economy. According to the National Center for Education Statistics, females account for the majority of college students, with 11.5 million females to only 8.7 males.[1] As the Pew Research Center demonstrates, there is a particular increase in college enrollment in the number of Hispanic and African American females when compared to their male counterparts.[1] Given all of these considerations about the importance of STEM education to our nation's economic future, one of the central goals of any national education policy must be to enable more of our students, especially those from underrepresented or disadvantaged groups populations, to plug in to opportunities to study and succeed in STEM fields as early in their studies as possible. Afterschool STEM programs are essential to this strategy, as they both expand and broaden the STEM ecosystem. The goal of STEM policy should be to create a country where access to STEM education does not depend on where a child lives, or on their background.

Out-of-School Learning must be a critical element in an overall strategy to improve STEM education.

Over the past several years, the STEM education community has increasingly embraced informal education programs as a mechanism for strengthening STEM education. If we want to employ an "all hands on deck" approach to improve STEM, we must fully utilize the opportunities presented by out-school, informal, and afterschool learning environments.

Emerging research is demonstrating very clearly that out-of-school STEM programs contribute to both academic and social measures of student success.

A major study published in *Science* in 2006 found that "professed interest in STEM careers by eighth grade was a more accurate predictor of getting a science-related college degree than were the math or science test scores of those same eighth-grade students."[6] More than a decade of increasingly comprehensive studies have reinforced the notion that informal learning can make concrete, measurable contributions to student success, not only in the classroom environment, but in broader measures of youth development, maturity, and career success.

Two representative studies of specific out-of-school programs, 4-H and FIRST Robotics Competition, conducted by major non-profit organizations are representative of emerging data on the impact of in-depth educational STEM experiences on student success.

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[6] Tai, R.H., Liu, C. Q., Maltese, A.V., & Fan, X. (2006, May 26).Planning early for careers in science. *Science*, 312, 1143-1144.

In 2011-12, 4-H, which reaches more than 6 million students through its youth engagement efforts, performed an evaluation of its Science Initiative using information gathered from a Youth Engagement, Attitudes and Knowledge (YEAK) survey.[7] Their findings indicated that:

- More than 80 percent of respondents intend to finish college or continue to pursue more education after college and fifty percent of respondents want to pursue a science career.
- Seventy-one percent of participants in the STEM group 4-H Science said science is one of their favorite subjects.
- Sixty-eight percent do science-related activities that are not for school work.
- Fifty-nine percent would like to have a job related to science when they graduate from school.

In a similar effort, Brandeis University's Center for Youth and Communities conducted an independent survey of FIRST Robotics Competition participants (ages 14-18), of which there are annually more than 70,000, and compared them to peers who did not have this opportunity. [8]

They found that FIRST students are:

- More than three times as likely to major in engineering when they go to college
- Roughly ten times as likely to have had an apprenticeship, internship, or co-op job in their first year of college.
- Significantly more likely to expect to achieve a postgraduate degree.
- More than twice as likely to expect to pursue a career in science and technology.
- Nearly four times as likely to expect to pursue a career in engineering.
- More than twice as likely to volunteer in their communities.

[7] 4-H Council. (2010). Evaluating the 4-H Science Initiative: The 2010 Youth, Engagement, Attitudes and Knowledge Survey Results. Retrieved from http://www.4-h.org/uploadedFiles/About_Folder/Research/Science/Final%20YEAK%20Report.pdf
[8] http://cyc.brandeis.edu/partners/FIRST%20Robotics.html

Out of school opportunities can power up both parents and kids!

A study of the U.S. Department of Education's 21st Century Community Learning Centers (21st CCLC) program, the only federal funding source exclusively dedicated to afterschool programs, showed that participating students had fewer absences and less tardiness, higher grades, higher rates of homework completion, and increased rates of parental involvement in school.[9] STEM learning is now a priority for 21st CCLC nationally and 12 states now encourage afterschool programs to include STEM programming in their applications.

After a 15-month review of the current evidence base, the National Research Council's (NRC) Board on Science Education concluded in a recent 2015 study that out-of-school programs have been shown to:

- contribute to young people's interest in and understanding of STEM,
- connect young people to caring adults who serve as role models, and
- reduce the achievement gap between young people from low-income and high-income families."[10]

Further, the NRC found that:

> "Research and evaluation findings are not yet robust enough to determine which programs work best for whom and under what circumstances. The limitations of the existing research are due to the many types of out-of-school STEM programs, and the difficulties of measuring the outcomes of such programs. **The findings are strong enough, however, to identify three criteria of programs that produce positive outcomes for learners: they are engaging, responsive, and make connections."[11]** *[Emphasis added]*

Afterschool and summer learning programs around the nation have enthusiastically embraced STEM programming and are engaging children and youth in STEM learning—including those who may not otherwise be selected to, or choose to, participate in STEM programs. A recent study showed that 7 million children are participating in afterschool STEM programs in the United States.[12]

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[9] Afterschool Alliance. (2011, May). Afterschool: A Vital Partner in STEM Education. *Afterschool Alliance.* Retrieved from http://www.afterschoolalliance.org/Afterschool_as_STEMpartner.pdf

[10] National Research Council. (2015). Identifying and Supporting Productive STEM Programs in Out-of-School Settings. Committee on Successful Out-of-School STEM Learning. Board on Science Education, Division of Behavioral and Social Sciences and Education. (Page 2)

[11] National Research Council. (2015). Identifying and Supporting Productive STEM Programs in Out-of-School Settings. Committee on Successful Out-of-School STEM Learning. Board on Science Education, Division of Behavioral and Social Sciences and Education. (Page 3)

[12] (Afterschool Alliance, 2015). *Full STEM Ahead: Afterschool Programs Step Up as Key Partners in STEM Education.* Retreived from http://www.afterschoolalliance.org/AA3PM/

There has been a significant effort to define frameworks for youth outcomes[13] in afterschool STEM programs and to document evidence of impacts.[14] These programs host varied modes of intervention, allowing educators to match learning experiences to student interests and to use project-based learning that drives home the relevance and importance of STEM in daily life. The afterschool setting uniquely gives young people the opportunity to learn through solving problems and through failing—an experience crucial to research, experimentation and innovation and developing the persistence the fields require.

We know that high-quality out-of-school STEM learning programs are strong contributors to improving student learning in STEM fields. We also have a good idea of what we don't know, and that we must keep investing in research to help answer lingering questions about which forms of out-of-school learning work best in a diverse range of settings and communities.

[13] *Defining youth outcomes for STEM learning in afterschool*. Retrieved from http://afterschoolalliance.org/STEM_Outcomes_2013.pdf
[14] *Examining the impact of afterschool STEM programs.* Retrieved from http://afterschoolalliance.org/ExaminingtheImpactofAfterschoolSTEMPrograms.pdf

Part Two: What We Must Do to Make Informal Education a Core Aspect of STEM Education Policies

Students develop an understanding of STEM concepts and skills through immersion in a wide array of learning experiences that take place both in out-of-school programs and in school. Just as language immersion builds fluency in languages, STEM immersion will help to build literacy and fluency in STEM knowledge and skills. This immersive learning process demands that federal policies support programs that will deliver valuable out-of-school STEM and link them to learning in the classroom.

In developing criteria for successful informal STEM programs, the National Research Council concluded that there were three characteristics of successful informal STEM education programs:

> **"Productive programs engage young people intellectually, socially, and emotionally.** Productive out-of-school STEM programs provide young people with firsthand experiences with STEM phenomenon and materials, engage them in sustained STEM practices, and are aligned with participants' cultural resources and practices. In such programs, young people are engaged in firsthand, materials-rich, and place-based learning experiences that involve processes of scientific or engineering investigation and practice. Thus, productive out-of-school STEM programs engage young people in the processes of doing STEM in ways they find compelling and challenging, and develop their interest, understanding, and commitment to continue engaging in STEM learning.
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> **Productive programs respond to young people's interests, experiences, and cultural practices** Productive out-of-school STEM programs make STEM relevant to the questions that interest young people, support collaboration and leadership by young people, and train staff to support and build young people's STEM activities and interest. Productive out-of-school STEM programs are also responsive to young people's prior interests and experiences so that they can see STEM as meaningful and relevant to their own experiences and aspirations.
>
> **Productive programs connect STEM learning in out-of-school, school, home, and other settings** Productive out-of-school STEM programs explicitly help young people make connections among STEM experiences in and across settings and programs, leveraging community resources and partnerships and brokering ongoing opportunities to engage in STEM learning activities. Productive out-of-school programs also help young people understand how what they experience and learn relates to learning in other settings, including school. Thus, productive out-of-school programs purposefully help young people, their parents, and others in the community capitalize on developing expertise and interests across time and setting."

Student engagement in STEM activities in informal settings is too often considered an afterthought, but as we have seen, this view is not reflected in the rapidly expanding body of evidence about outcomes from informal learning.

Federal policies that seize on afterschool programs and their unique role in inspiring interest and success in STEM education will engage more young people in the STEM fields so important to the future of our country.

A Federal Informal STEM Education Policy Agenda

As the number and diversity of out-of-school programs that support STEM learning supported by both private sector and government funding continue to grow, it is becoming increasingly important for policy makers to make informed decisions about which programs to support. Considering the enormous potential of informal learning opportunities to enhance the impact of efforts to improve STEM education, a broad-based federal public policy agenda must address the following needs:

- **Informal education as a core STEM strategy:** Informal education should be viewed by policymakers as a core strategy for enhancing and improving STEM education and informal educators and programs must be considered as valuable partners for STEM education improvement efforts. Out-of-school opportunities support STEM learning independently from classroom learning, much like the way multiple pollination points boost an ecosystem.

- **Integration of informal learning:** Broad-based STEM education reform efforts must integrate informal STEM education opportunities, immersing students in STEM much like they are immersed in a language. This includes stipulating informal programs as eligible partners for federal grant funds that support STEM education goals.

To enable success, the following supports must be in place:

- **Dedicated Funding:** Recognizing the unique role of informal STEM education programs to build interest, identity and skills in a way that is different from school-day learning, there must be dedicated funding streams available for such programs.

- **Professional development:** Afterschool learning practices must be integrated into federal professional development programs for STEM educators. Federal professional development programs must support professional development for both teachers and afterschool educators to ensure complementary STEM content delivery and effective implementation of high-quality K-12 math and science standards.

- **Federal coordination and management:** The executive branch must develop and implement a comprehensive federal strategy to coordinate and manage investments in

informal STEM education programs, resources and activities. Such a strategy must include a strong mechanism for including informal STEM education stakeholder inputs in the formulation of federal agency priorities, goals and policies.

How will we know that our efforts have been successful?

- **Knowledge base:** Budgets must prioritize investments in educational research programs to build the knowledge base about what works in afterschool and other informal STEM education programs. To expand research-based knowledge about productive strategies to support STEM learning in out-of-school settings and programs, there is a need to invest in research that documents both the learning that occurs in individual programs and also how STEM learning develops across settings and over time through a wide variety of opportunities.

Spending time in programs outside of school that focus on STEM subjects gives all students the opportunity to experiment with STEM ideas in real-world situations. Such opportunities help spark curiosity, especially for those who might not think of themselves as "math and science kids." Additionally, out-of-school opportunities are particularly well suited to sparking interest in STEM and building identity as a STEM learner.[15] STEM education stands to be greatly improved by taking advantage of the complementary nature of formal and informal learning opportunities, which includes after-school programs. Settings like afterschool and summer learning programs can be thought of as pollination points in a wider STEM ecosystem, where having multiple locations to learn reinforces students' developing mastery of science, technology, engineering and mathematics skills. We all benefit when more of our children have a fair and equal chance to live up to their potential and contribute to our society.

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[15] National Research Council. (2009). Learning Science in Informal Environments: People, Places, and Pursuits. Committee on Learning Science in Informal Environments.