Recommendations submitted to the State Superintendent of Public Instruction, Tom Torlakson and the STEM Task Force by the Out-of-School STEM Task Force December 21, 2012.

Background

The California AfterSchool Network (CAN) provides out-of-school time practitioners, advocates, and community members with the resources and tools necessary to build high quality out-of-school time programs in California so every young Californian next can have daily access to the kinds of enriching experiences that enable them to maximize their potential.

We strive, using every appropriate forum and technology, to bring stakeholders together to share best practices, to build skills, to learn about resources they can build from, and to develop new leadership that can extend the reach of high-quality OST programs into areas where few exist today.   The Network operates through seven working committees that each concentrate on a particular after school field. These committees help to carry out the essential work that is required to move their various fields forward.

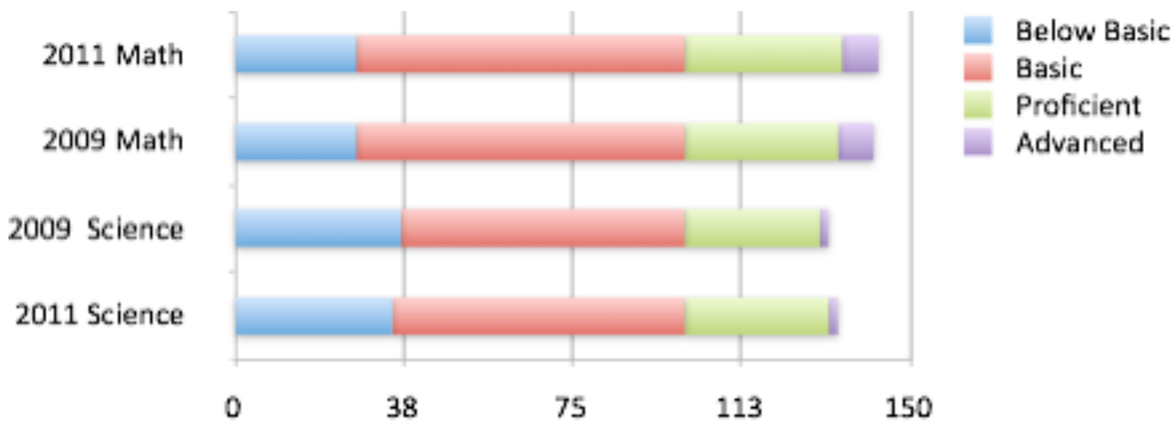
One of these, the STEM (science, technology, engineering and mathematics) Committee, is dedicated to providing all of California's children with access to high-quality and engaging learning experiences in STEM. The Committee accomplishes this in part by working to bring the formal and informal STEM education community together to work towards the common goal of dramatically improving STEM literacy and proficiency across the state. The Committee formed a Task Force and charged it to develop recommendations that could aid the CDE STEM Task Force in its efforts to improve STEM education in the State. Our recommendations identify certain issues that hamper STEM learning in California and suggest ways that we believe OST programs could be leveraged to help break through these barriers.

The recommendations are organized into four broad categories:

1. Invest in professional development to support STEM in OST.
2. Leverage OST to increase access to high quality instructional materials and resources (expanding the resource base).
3. Leverage OST to scale promising practices, strategies, and exemplary models.

4. Leverage OST to assess success (increase interest in STEM subjects and fields including formative assessment). Introduction

National Assessment of Education Progress – U.S. Mathematics and Science



Unless things change quickly, the next generation of Americans will be unprepared to deal with the daunting environmental and technical challenges they will surely inherit. Sixty-five percent of eighth graders in the United States scored below proficient in science and seventy-three percent scored below proficient in mathematics (NAEP, 2011).

In California, approximately seventy-five percent of all students score below proficient in science and mathematics. The situation is even more dire for students from either lower-income backgrounds or communities that are traditionally underrepresented in the sciences. In 2011, for example, only 12 percent of Black eighth grade students scored proficient in math compared to 41 percent of Caucasians. According to the NAEP report, students "who were eligible for free/reduced-price school lunch, an indicator of low family income, had an average math score that was 29 points lower for than students who were not eligible for free/reduced-price school lunch" (NAEP, 2011, p.2).

At a time of high unemployment and low student achievement in STEM subjects, jobs requiring technical skills are on the rise. There are currently 1.4 STEM jobs available for every 1 unemployed person in California while at the same time there are 4.9 unemployed people for every 1 non-STEM job. Young people need opportunities to become engaged in

STEM learning experiences in order to increase the number of students interested in a STEM-related career (Vital Signs, 2011). Clearly, if California is to succeed in the global economy of the future then our State must solve the STEM education crisis it has today.

In the present environment of high stakes testing, California teachers are rarely able to devote much time to subjects other than math and language arts because of the pressure of meeting AYP (Annual Yearly Progress) for these is tested every year. In contrast, California students' proficiency in science is only assessed once every four years. This loss of emphasis on STEM has diminished California's capacity to address the problem. For example, the level of professional development elementary school teachers receive in STEM is now so low that many believe themselves to be unprepared to offer high-quality STEM learning experiences to their students. Eight-five percent of teachers have had no science related training in the last three years (CTL- West Ed. 2011). Without this essential professional development for our educators, our students cannot receive the types of STEM learning experience that are critical to their futures.

OST programs offer a way forward. They are ideal platforms to test out new ideas, and many provide student-centered, inquiry-based, project-based approaches to STEM learning that compliment core instruction and align perfectly with the thrust of efforts that are currently underway to reform STEM education.

In California, state and federal funding supports over 4,500 after school programs serving approximately 450,000 students. These programs serve exclusively low-income communities, many with high levels of English Learners (State of the State, 2012). These OST programs provide flexible learning environments where young people can engage in hands-on, inquiry-based, student-centered, quality STEM learning opportunities that are not typically offered in the core instructional day. On average, after school programs offer an additional 540 hours per school year, which is the equivalent to 77 additional school days. This time is critical and can be used to provide STEM programs to the communities that need them the most. It truly is an opportune time for after school STEM programs to be part of a comprehensive plan to increase quality STEM learning statewide.

The new After School Programs (ASP) Division, headed by Michael Funk, recently released a report on its strategic initiatives. The ASP is critically reviewing its system of technical assistance (TA) so as to make it much more effective. The ASP is also seeking to increase the role that after school programs play in extended day programs throughout K-12.

In terms of STEM programs, the California After School Network, in partnership with the California STEM Learning Network, have launched a new initiative that aligns perfectly with the ASP's vision. It's called the Power of Discovery: STEM^2 Initiative. STEM^2 will leverage well-established STEM education organizations as Regional Innovation Support Providers to help support over 1,000 OST STEM programs across the State with assessment, planning, and targeted technical assistance. These systems of supports are ripe to be leveraged to increase access that young Californians have to high-quality STEM programs after school.

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Chapter 1 – Professional Development

Introduction

Professional development is key to supporting effective STEM instruction and the improvement of student achievement. The committee calls for dramatic departure from current practice in both intensity and kind. Much of the existing research and surveys of the field of out-of-school-time (OST) science and STEM indicates that the vast majority of OST staff do not have professional or academic backgrounds in STEM. Additionally, OST staff report that they do not receive professional development in STEM topics or STEM education, and would like to receive more. The recommendations in Chapter 1 of this report address professional development for OST staff and the community of paraprofessionals and volunteers engaging with OST.

Definition of Staff Development used:
"There are many different definitions for staff and professional development. This document uses the broad definition provided by the Out-of-School Time Resource Center for Promising Practices in Out-of-School Time Professional Development: 'activities, resources, and supports that help out-of-school time practitioners work with or on behalf of children and youth.'"
(Strengthening After School STEM Staff Development. Freeman, Dorph and Chi. Coalition for Science After School, 2009.)

The Recommendations

1. Professional development opportunities should be ongoing throughout the term of service for after-school staff and volunteers. Staff and volunteers should be trained to 1) effectively manage a group of 20 students, and 2) facilitate STEM activities with knowledge and confidence.

a. After School staff and volunteers should be introduced to the basic concepts of the NRC's publications - How People Learn, How Students Learn Science, and Surrounded by Science.
b. After School staff and volunteers should be introduced to the rationale and methods of inquiry and project-based learning/instruction, and deepen understanding of scientific and engineering practices in STEM.
c. After School staff and volunteers should be introduced to the positive connection between the principles of youth development (commonly at the core of after school or out-of-school-time organizations) and STEM education.
d. After School staff and volunteers assigned to STEM should participate in ongoing trainings that deepen their content knowledge of STEM subjects.
e. After School STEM staff and volunteers should be provided with opportunities for structured reflection after the facilitation.
f. After School STEM staff and volunteers should be provided with opportunities for direct interaction with materials and content prior to facilitating activities with youth.
g. Utilize online training and webinar options for cost-effectiveness (i.e., NSTA's Learning Center).

2. After-school sites or programs should recruit, train, and retain one staff member assigned to teach STEM (STEM Lead). This staff member will be responsible for meeting the goals for OST STEM.
    a. The state should assist after-school agencies in recruiting and training STEM leads statewide to build capacity.
    b. The state should provide incentives for after-school STEM leads to commit to at least 3 years of service.
    c. Create a defined pathway for aspiring teachers (pre-service students) to earn credit for after-school internships.
    d. Create a program with incentives for retired STEM teachers to provide expertise.

e. Develop standards for hiring to ensure low turnover rates and knowledge of subject matter.
f. Create directory of "traveling STEM Leads" or service providers (vendors) that can rotate between sites unable to maintain their own STEM staff member.

3. Provide regional after-school STEM experts to provide support and guidance to a number of after-school sites in their region if local experts are not available.
    a. Establish networks of regional informal STEM educators and staff (museums, make communities and organizations, science centers, etc.) as resources for formal and informal professional development experiences as well as resource networks for after-school staff and volunteers.
    b. Provide after-school STEM staff and volunteers with opportunities to network with STEM staff and volunteers at other schools throughout the state. Highlight schools with exceptional programs throughout the state and share best practices.
    c. State to develop and maintain an online database of STEM resources for after-school agencies and STEM staff. Identify resources already available to avoid reinventing the wheel.
    d. Match volunteers with OST staff to allow for in-service professional development of both volunteer and OST staffer, as well as to improve real-time facilitation of the activity/experience with youth.

4. Provide after school staff with the responsibility of delivering STEM to ELL students training on how to integrate language acquisition and STEM learning.
    a. Effective professional development results in positive change in teachers' beliefs and practices in integrating science and literacy for ELL students
    b. STEM instruction should provide ELL students with a meaningful learning environment and opportunities to engage in scientific discourse.

Conclusion

The above recommendations for STEM-focused professional development for OST staff and volunteers share in many ways mirror best practices of professional development for teachers. However, the recommendations are notable in the degree to which they make a case for support relationships within the OST organization and externally with formal and informal STEM institutions.

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Chapter 2 – Increase access to high quality instructional materials and resources consistent with quality learning in OST STEM.

Introduction

Improvements in U.S. STEM education are lagging and comparisons show that U.S. students fare poorly in comparison with students in other countries. In addition, gaps in mathematics and science achievement persist between student population groups: the black/white, Hispanic/white, and high-poverty/low-poverty. Currently, standards and many widely used curriculum materials do not represent what is known about children's thinking, especially the cognitive capabilities of younger children. Going back to 1983, no less than twenty-four previous K-12 STEM education reports included strong recommendations for improving K-12 STEM curriculum (see Additional Resources). It is time to take a World View of OST STEM for California. International U.S. proficiency in STEM is ranked about 3, where 1 is the lowest, and 5 is the highest. Three (3) is the world average. California is ranked 47th in the U.S. for mathematics and science achievement. Just catching up to the rest of the U.S. would mean we are then internationally average, which is considered mediocre compared to the Presidents goal of being first internationally by 2016. The call for additional resources to support these recommendations for OST STEM cannot be ignored.

The Recommendations

5. Developers of curriculum and assessment for OST STEM should revise their frameworks to reflect the new K-12 Science Framework, NGSS, and the Common Core State Standards.
    a. STEM curricula should be focused on the most important topics in each discipline, be rigorous, and articulated as a sequence of topics and performances.
    b. Curriculum should keep children actively engaged in designing and creating projects to explore concepts.

c. Curriculum should support using all practices and crosscutting concepts to teach all core ideas all year
d. Curriculum should integrate science and engineering.
e. Curriculum should reflect the world of work and engage students with digital media as well as traditional media. Technology rich learning environments should be provided when possible.
f. Curriculum should coordinate with the Common Core State Standards in Mathematics and ELA.

6. Staff responsible for the selection and implementation of curricular materials should receive intensive professional development in selecting and using high-quality STEM.
   a. Facilitates making the appropriate selections based on knowledge and use of scientific and engineering practices inherent in the Next Generation Science Standards.
   b. After-school STEM staff and volunteers should be provided with opportunities for direct interaction with materials and content prior to facilitating activities with youth.
   c. State to develop and maintain an online database of STEM resources for after-school agencies and STEM staff. Identify resources already available to avoid reinventing the wheel.
   d. Provide after-school STEM staff and volunteers with opportunities to network with STEM staff and volunteers at other schools throughout the state. Highlight schools with exceptional programs throughout the state and share best practices.

7. Promote free CASRC Resources: Raising awareness about materials available from the California After School Resource Library (CASRC) at www.californiaafterschool.org is a cost-effective way to ensure materials selected for use by after school staff are standards-aligned, research-based, and appropriate. In addition, CASRC offers free Online Trainings that address basic STEM concepts (e.g., inquiry-based learning). These free resources need to be further promoted and utilized by the OST field.

8. Identify exemplary programs and resources across the state: Promising practices and programs should be supported and disseminated. Examples include the Young Makers Network, the Community Science Workshop Network, Techbridge, MESA, MOUSE Squad, LabRats, and SAM Academy. Resources developed by industry and public works agencies such as Exxon, Intel, Chevron, Forestry Products, Department of Energy, EPA, etc., Other similar programs and practices should be identified and combined into a database of promising practices for California OST STEM.

9. Programmatic Needs: Individual programs have unique student populations and programmatic needs. Instructional materials that appeal to students with special needs, such as English Learners, Special Needs students, or advanced learners, need to be identified and considered to with a focus on inclusion.

Conclusion

Innovation is a stand against complacency. Improvements in curriculum and assessment are expected with the implementation of the Common Core State Standards and the Next Generation Science Standards. These new standards, curriculum, assessments, and instruction should become a coordinated system to support innovations in student learning. Access to high-quality instructional materials is often facilitated by site coordinators and leadership at the site level.

This particular segment of the workforce would benefit from intensive professional development in selecting and using high-quality STEM materials so they can make the appropriate selections and secure proper training for their staff. OST frontline staff may be at various stages of readiness to integrate STEM. Thus, the options of resources available to them must be flexible. However, flexible does not mean sub-standard. They should have access to engaging instructional materials that complement school-day learning and reflect real-world situations. Cost-effective materials management is an important factor for ensuring ongoing access. Many STEM activities and lessons require consumable supplies and components that need to be replaced. Programs must allocate the funds necessary to sustain the level of instruction and consider the creation of collaborative to cut costs for materials as a region.

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Chapter 3: Scale and disseminate promising practices and strategies and exemplary models in OST STEM.

Introduction

Quality teaching is never an accident. It arises only when educators are well versed in the best pedagogy and management practices of their day. It is therefore vital for every member of the OST STEM community to have a convenient way to learn about the strategies and methods behind the successful OST STEM programs. Moreover, since teachers are always experimenting with new ways to inspire young people to become lifelong STEM learners the community needs to be prepared to take advantage of their discoveries. OST STEM programs have considerable freedom to choose both what they teach and how they teach it. As a result, these programs can be great incubators for innovative new approaches for engaging youth in STEM. To build continuous improvement across the community, promising new practices and strategies need to be identified and disseminated as they appear.

The Recommendations

10. Identify criteria that define what it means for an OST STEM program to be an exemplary model. Clearly, an exemplary program should inspire its students to want to learn more STEM and to apply STEM concepts in the real world. Metrics that quantify these desires include, but are not necessarily limited to:

a. Increased student self-efficacy in STEM.
b. Increased motivation to learn STEM in formal and informal settings
c. Students become more likely to take challenging STEM courses.
d. Students become more likely to seek new STEM learning experiences on their own.
e. Improved academic performance
f. Caused students to try to engage their peers in similar STEM experiences.

11. Create a database of exemplary OST STEM programs, and then identify and disseminate program elements they tend to have in common. Prior research has already identified some of these elements, which can be disseminated immediately. These include:

a. Student-centered. They engage students in relevant and meaningful STEM activities and projects, and incorporate character development and youth leadership.

b. Create STEM-centered social learning environments that bond young people strongly together into a mutually supportive community.

c. Teach team skills and collaboration, promote tolerance and compassion, and inspire a desire to give back to their communities.

d. Move students to consider the role they want STEM to play in their futures as learners, earners, and citizens.

e. Motivate student advancement by publicly recognizing achievement to enhance the achievers' social status amongst their peers.

f. Incentivize student engagement through youth-centered programming that students see as personally empowering and socially relevant.

g. Incorporate as mentors STEM experts of high character to guide learners on matters of science, character, and careers.

h. A number of organizations have investigated what makes for a successful OST STEM program. For instance, Learning in Afterschool & Summer identifies a set of five learning principles as essential: 1) Learning that is active. 2) Learning that is collaborative. 3) Learning that is meaningful. 4) Learning that supports mastery. 5) Learning that expands horizons. Organizations with expertise in this area should be consulted.

12. Create tools that assess the extent to which any given OST STEM program is ready to attract students and to provide them with an exemplary STEM experience. Specifically, the community needs to develop:

a. Comprehensive Readiness and Needs Assessments that address all major facets that OST STEM programs must have to be successful including, when applicable (e.g. for community-based programs that are run by non-profit organizations) marketing and business plans.

b. Observational assessments performed at the point of service.

c. Summative assessments that quantify the impacts a program has on its students including:

i. Changes in STEM related interests and attitudes.

ii. Degree to which the program complements the school day through applying the processes, concepts, and habits of mind that meet the Common Core State Standards and the Next Generation Science Standards (when adopted).

iii. Level of student engagement in STEM activities outside the program

iv. Integration of scientific habits of mind outside the program.

v. Degree to which the students believe that the program has involved them in meaningful projects that are relevant to them.

d. Assessments that measure the impact the program has on the greater community that it serves.

13. Foster continuous improvement both by providing independent assessment of programs that claim to have developed promising new practices, strategies, and models, as well as by broadly disseminating the resulting data to the OST STEM community.

14. Create opportunities for practitioners to share their promising practices and models widely throughout the OST STEM community and to encourage their adoption and implementation.

15. Provide professional development and training for program planners, managers, and frontline educators using all appropriate methods and technologies. When possible, leverage existing communication vehicles to provide online, person-person, and print materials using the Technical Assistance infrastructure.

16. Leverage existing programs, legislation, and initiatives such as the California Science Project, California Mathematics Project, CSU Math/Science Teacher Initiative and CA teacher pathways to use OST STEM programs to develop STEM teachers and paraprofessionals that understand student-centered learning in the informal OST environment.

Conclusion

The great potential of the OST STEM community to advance STEM education comes from its diversity of its educational philosophies and its independence from formal education. Unfortunately, those same qualities make it difficult for the community as a whole to identify, disseminate, and incorporate innovative and effective practices and strategies as they are developed and proven. We believe that by leveraging existing resources it is possible to be infrastructure for collaboration that can promote continuous improvement broadly throughout the OST community, and that these recommendations point the way.

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Chapter 4: Assessing Success In OST STEM

Introduction

The future of OST STEM is sure to engage many more STEM savvy citizens in the private sector than it does today. This means that in addition to programs that are run by certified teachers on public school campuses there will also be many more new programs that will be run by STEM experts with no teaching credentials out of science centers, church rec. rooms, and public parks.

While that prospect is exciting, the situation calls out for new tools that can meaningfully assess needs, readiness, and success of all OST programs in this ever expanding and evolving community. Developing those new instruments won't be easy. Consider, for instance, that while a school-based program may have a monopoly on students in the school, programs that operate out of science centers must compete for their students against every company with after-school offerings in their area. As a result, what constitutes a "need," "readiness," and even "success" for a given STEM program can depend very much on whom its leaders intend to serve.

The success of any school-based or community-based education program, STEM or otherwise, must be defined, at least partially, in terms of how far it advances its students' understanding of whatever subject it teaches. STEM programs can go further because they have the potential to empower students not only with knowledge but also with skills and attitudes that can create new knowledge. The best STEM programs deliver powerful emotional experiences that can lead to lifelong learning and even to careers in a technical field. What's more, community-based programs often also have measurable impacts on the communities in which they operate. Clearly, folding these sorts of impacts into the wider definition of "success" requires broad-reaching metrics that, when taken together, assess all the potential effects that STEM programs can have.

If the people who design OST STEM programs are going to seek to achieve this broader definition of success, they need to incorporate elements that are known to create it. Unfortunately, the formative Readiness and Needs Assessment (RNAs) we have today are inadequate to guide them.

The existing summative assessment tools are also lacking. Today's instruments were developed for the most part to meet the needs of in-school standards-based STEM education and they tend to be skewed strongly towards measuring how well students know state-mandated content. Quantifying the full measure of an OST program's impact on its students and its community requires new the development of a new generation of assessment tools.

(NOTE: We realize that some of the specific suggestions bulleted below may appear to the experienced professional to be utterly impractical to implement. However, since history teaches that new techniques and technologies often convert impractical things into trivial ones, we have chosen not to omit these items in the hope that they will inspire the invention of new practical methods and means to enact them.)

The Recommendations

17. Develop a set of summative assessment tools that provide meaningful measures of an OST STEM program's total impact on its students and on its community. Use existing assessment tools where they exist and encourage the development of new tools where they don't. The assessment could be divided into the following subject areas and gather information from the following sources.

a. Cognitive Development:

a) Identify or develop assessments to identify and rank specific aspects of one's social environment that support STEM learning.
b) Identify or develop assessments to measure what is taught.
c) Identify or develop assessments that provide evidence of learning.
d) Identify or develop assessments that probe for student understanding.
e) Identify or develop assessments to track the inculcation of scientific habits of mind.
f) Identify or develop assessments that track the emergence and development of adaptive expertise.
g) Parent/guardian assessments to identify changes in behavior, attitudes, interests, problem solving methods, etc.

h) Develop longitudinal research designs for OST programs that engage individual students in long-term projects.

b. Social Development

a) Identify or develop assessments that track the emergence and development of positive character traits such as a sense of personal responsibility, a desire to give back to the community, commitment to the ethical treatment of others, the ability to work in teams, and so on.

b) Parent and family STEM learning and involvement.

c) Standard personality inventories such as the CPI or the MMPI.

c. Direct Community Impact: Survey community leaders that were involved with the student during a community-based STEM project.

d. Indirect Community Impact: Survey key stakeholders to determine the "distribution" effect that comes about when students network within the context of STEM.

The ability to measure Indirect Community Impact could prove to be quite important. Young people spread their excitement about something to their like-minded friends, including those on their extended social networks. Getting others to be excited about STEM might impact the attitudes and the academic performance of students who are not themselves involved with the program, who themselves might ultimately spread their excitement on to some of their friends. If OST programs developed methods and resources to enable STEM interested students to pass their interest on to others then is possible that passion for STEM could "go viral" and expand rapidly around the world. Clearly, it is important to find a way to quantify this (for lack of a better term) "evangelist effect."

18. To help promote continuous data-driven improvement throughout the OST STEM community, we recommend a set of "quality metrics" be developed that combine all of the individual summative metrics into a few numbers that quantify the success of any OST STEM program in terms of a set of (to be determined) "meaningful" categories, as well as a metric that defines the combined or "overall" success of the program, so that all these programs can be objectively ranked and compared. This would incentivize underperforming programs to adopt the best practices of one or more exemplary (highly-ranked) programs.

19. Develop a comprehensive "Readiness and Needs Assessment" (RNA) that can guide educators towards creating OST STEM programs that achieve the broadest possible measure of success as defined by the new OST STEM Summative Assessment. We wish to stress in particular the need for the formative assessment to help prepare the program to be ready to:

a. Recruit and retain high quality teaching staff.

b. Deliver intensive staff development frequently for as long as the program runs.

c. Engage parents to be meaningfully involved in their child's educational experience.

d. Engage parents to help assess changes in attitudes, habits of minds, interest in STEM, personal character, and so on, which their children demonstrate at home.

e. Track any STEM "evangelist effect" that the program generates.

f. Attract and retain students at or near the program's capacity.

g. Thrive in the marketplace in which it operates.

h. Collect and analyze data that will help the program achieve its mission as effectively and efficiently as possible.

i. Collect, analyze, and disseminate data that could be beneficial to the greater education community (e.g. new practices in STEM education or teacher training).

Conclusion

OST STEM programs cannot achieve their true potential until new formative and summative assessment instruments are developed to address these programs particular needs, expand their capabilities, and take advantage of the unique opportunities that exist in OST STEM. Since many OST STEM educators are not certified teachers, and many of these programs operate outside the public schools, these new instruments must be broader and more comprehensive than what would be necessary for in-school teacher-lead programs. We hope that the recommendations above will prove useful in the development of these new instruments.

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Additional Resources

http://www.afterschoolnetwork.org/

http://www.afterschoolalliance.org/STEM-PUBLICATIONS.CFM

http://www.hfrp.org/out-of-school-time/ost-database-bibliography - Keyword: STEM

Readiness and Needs assessment tool from the California Afterschool Network:

http://www.powerofdiscovery.org

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