

The Power of Discovery: STEM² 2013-14 Report

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Executive Summary

This report presents the findings of the first full year of the implementation of the *Power of Discovery: STEM²* Initiative that occurred during the 2013-14 academic year. The Power of Discovery (PoD) Initiative is guided by a logic model in which systemic support of afterschool STEM programming (the “treatment”) is posited to facilitate improvements in staff beliefs about STEM, and program activities, which are posited to then support gains in STEM-related student outcomes. During 2013-14, a research team from the University of California, Irvine (UCI) collected systematic data to test this logic model.

Six specific aims guided the analyses.

AIM 1— TO DOCUMENT THE CHARACTERISTICS OF THE AFTERSCHOOL WORKFORCE OF PARTICIPATING PROGRAMS

- Staff surveys were collected from 173 staff at 96 program sites.
- Program staff were ethnically diverse (47% Latino/a, 26% Anglo).
- One quarter of the staff reported a B.A. degree; 1% had a Masters degree; 16% had an AA degree. Most (54%) reported “some college.”
- Staff were relatively young, 50% were between 18 and 25 years old.
- There was a relatively high staff turnover at the sites, with 55% of the line staff working at a program site for two years or less; 29% of the workforce reported having been at the site six months or less.

AIM 2—TO DOCUMENT PROGRAM-LEVEL CHANGES THAT OCCURRED DURING THE FIRST FULL YEAR OF IMPLEMENTATION OF THE POD INITIATIVE

- Staff reported their exposure to STEM-related material in the fall 2013 and spring 2014.
- The amount of STEM training attended by staff significantly increased from fall 2013 to spring 2014.
- Discussions with classroom teachers about STEM topics increased from fall 2013 to spring 2014.
- Frequency of staff members’ discussions with parents about STEM activities increased from fall to spring.
- Staff reported an increase in hosting events or meetings for parents such as science fair, family math nights.

AIM 3— TO EXAMINE RELATIONS BETWEEN STEM PROFESSIONAL DEVELOPMENT AND STAFF BELIEFS

- More frequent meetings among program staff to discuss STEM programming was associated with staff having stronger beliefs about the value of STEM activities and greater feelings of efficacy in implementing STEM activities.

- Discussion of STEM concepts with classroom teachers was associated with an increase in staff feelings of efficacy in implementing STEM programming.
- More training in STEM-related topics was linked to gains in staff beliefs about the value of STEM learning.
- Staff members who received more training reported greater efficacy in implementing STEM activities.

AIM 4— TO EXAMINE LINKS BETWEEN STAFF BELIEFS AND IMPLEMENTATION OF STEM ACTIVITIES IN THE PROGRAMS

- 84 staff submitted STEM Activity Documentation Forms documenting the implementation of 2,457 STEM activities.
- The most common grade levels receiving the STEM programming were students in Grades 4 and 5.
- Of the activities reported, science was most often the focus of the activity.
- Overall, staff reported that the STEM activities went well. The majority of activities were reported as “somewhat challenging” for students. For the majority of the activities, students were reported as being “very engaged.”
- Stronger staff beliefs about the importance of STEM activities were associated with higher levels of challenge and student engagement during the STEM activities.
- Greater staff efficacy was associated with higher levels of student engagement.

AIM 5—TO EXAMINE LINKS AMONG STAFF BELIEFS, PROGRAM ACTIVITIES, AND GAINS IN STUDENT OUTCOMES

- 2,957 students completed surveys in fall 2013 and spring 2014 in which they self-reported work habits, subject-specific efficacy in reading, math, and science, overall interest in science, science-related career aspirations, and perceived likelihood of future success.
- Staff beliefs about the importance and benefit of STEM activities were associated with relative gains in students’ self-reports of math efficacy.
- A higher level of staff-reported activity challenge was associated with relative gains in student self-reports of work habits, reading efficacy, math efficacy, science interest, and science career aspirations.
- A higher level of staff-reported activity challenge in STEM activities was linked to relative declines in student reports of misconduct.
- More time spent on STEM activities was associated with gains in math efficacy.
- An increase in staff discussions with classroom teachers about STEM topics was associated with an increase in students’ science efficacy and student-reported likelihood of a successful future.
- An increase in staff meeting with parents to discuss the programs’ STEM activities was associated with an increase in students’ math efficacy and science efficacy.

AIM 6— TO EXAMINE RELATIONS BETWEEN OBSERVATIONS OF STEM ACTIVITIES, STAFF BELIEFS ABOUT STEM, REPORTS OF PROGRAM ACTIVITIES, AND STUDENT OUTCOMES

- To accomplish this aim, observations were conducted at 52 program sites. Staff reports of STEM beliefs and STEM efficacy were collected at 36 of these sites, and staff completed Activity Documentation Forms at 29 of the observation sites. 1,949 students completed student surveys at all 52 of the observation sites.
- Of the Dimensions of Success¹ ratings, Space Utilization and Materials were the most highly rated dimensions and Youth Voice and Inquiry received the lowest ratings of all 12 dimensions.
- Science were the most frequently observed activity.
- Suggestive correlations were found between staff beliefs about STEM learning and observed Purposeful Activities, Youth Voice, and Positive Relationships dimensions observed using the DoS. Suggestive correlations also were obtained between staff reports of the quality of the STEM activities and observer ratings of Relationships and Reflection dimensions.
- A statistically significant association was obtained between observer ratings of Reflection and relative gains in student self-reported science efficacy.

CONCLUSIONS

In aggregate, findings from the 2013-14 study of the Power of Discovery Initiative suggest that:

- The Power of Discovery provided training activities and collaborative opportunities that supported the professional development of a diverse workforce.
- Staff development in the STEM area and collaboration with classroom teachers can serve as effective supports for the development of afterschool staff beliefs about the value of STEM learning and their perceived efficacy in implementing STEM activities.
- As posited in the logic model, these staff beliefs were found to be linked to the improvements in student engagement and interest, suggesting that staff beliefs may be a mechanism or strategy for impacting program activities.
- Staff beliefs and program activities were related to gains in student self-reports of math efficacy and to other student outcomes.
- STEM activities that are engaging and challenging can foster the development of students' interest and motivation in science and mathematics, including future careers in these areas.
- Suggestive correlations between observations of the quality of STEM activities and staff and student beliefs were also found.
- Taken together, these findings suggest that the PoD was effective during its first full year of implementation.

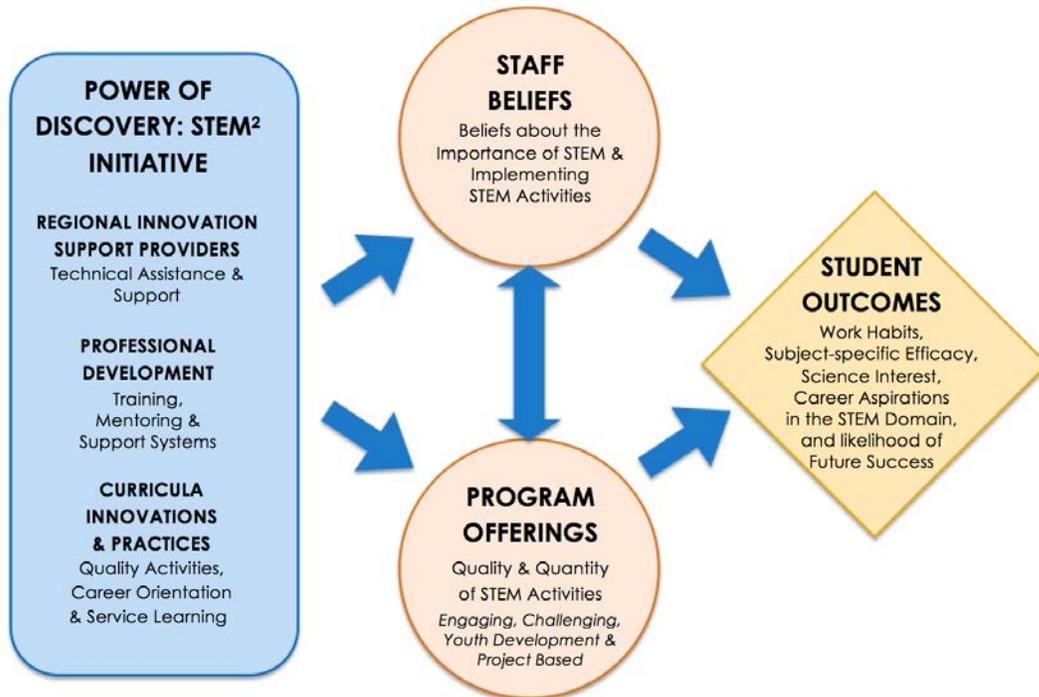
¹ The Dimensions of Success (DoS) is an observation protocol used for observing out-of-school time STEM activities. The DoS is developed by the Program in Education, Afterschool & Resiliency (PEAR). More information on this is provided later in the report and can also be located online. <http://www.ocde.us/STEM/Documents/Dimensions%20of%20Success%20Protocol.pdf>

Section I. Introduction

This report presents findings from the first full year of the implementation of the *Power of Discovery: STEM²* Initiative, which occurred during the 2013-14 academic year. The Power of Discovery (PoD) Initiative was guided by a logic model in which technical assistance and staff training in the STEM domain (the “treatment”) was posited to facilitate improvements in staff beliefs about STEM and STEM-related program activities in afterschool programs. These gains were posited to support improvements in student outcomes in STEM subjects. During 2013-14, a research team from the University of California, Irvine (UCI) collected systematic data to test this logic model.

Figure 1 presents the Logic Model underlying the *Power of Discovery: STEM²* Initiative. The Logic Model is a sequential one in which Professional Development and Curricula Innovation support provided by the Regional Innovation Support Providers (RISPs) and the Virtual Innovation Center (the “treatment”) is represented in the blue boxes on the left hand side of Figure 1. The treatment is expected to yield improvements in (a) Staff STEM Beliefs and (b) STEM-related Program Offerings. These improvements in Staff Beliefs and Program Offerings are expected to be mutually reinforcing, as illustrated by the bi-directional arrows in the Logic Model. The Staff Beliefs and Program Activities are then expected to yield desired improvements in student outcomes, the box on the far right of the figure. These student outcomes include work habits, subject-specific efficacy, science interest, career aspirations in the STEM domain, and the likelihood of future success.

Figure 1
The Power Of Discovery: STEM² Logic Model



The initial groundwork for the *Power of Discovery: STEM²* Initiative was completed in 2012-13 when five RISPs were selected following a statewide competition. The RISPs were charged with recruiting 625 afterschool programs in their regions to participate in an ambitious effort to improve STEM learning in afterschool programs. Participating programs were offered professional development, curriculum resources, the establishment of communities of practice, and interagency networks of support for programs in their regions.

The five RISPs are:

Northern California

1. Alameda County Office of Education (ACOE) and the Gateways East Bay STEM Network
2. Sacramento County Office of Education (SCOE)
3. Tech Museum of Innovation (TECH)

Southern California

4. OC STEM Initiative
5. San Diego County Office of Education (SDCOE)

During the initial planning year (2012-13), the RISPs were charged with building strong partnerships within the afterschool programs in their region by providing technical assistance to these programs, facilitating access to staff trainings and curricular resources and organizing networking opportunities. In addition to the RISPs, a Virtual Innovation Support Center was established by the California After School Network housed at the University of California, Davis, to host a range of vetted STEM curricula and program management resources to serve program providers throughout the state and nationally. During the 2012-13 year, a pilot of the measures used for data collection was administered to staff and students. This resulted in partial data for the spring of 2013. However, due to the incomplete nature of the data and the nascent state of the initiative during its initial year of implementation, analyses on these data were not conducted.

Following the creation of these relationships and support materials and resources in 2012-13, the Power of Discovery Initiative was in a position to be fully implemented at 600 sites during the 2013-14 academic year. A research team at the University of California Irvine was responsible for studying the effectiveness of the Power of Discovery Initiative during its first full year of implementation in 2013-14.

This investigation was organized around the systematic examination of six study aims.

Aim 1— TO DOCUMENT THE CHARACTERISTICS OF THE AFTERSCHOOL WORKFORCE OF PARTICIPATING PROGRAMS

This aim examines the afterschool workforce demographic compositions such as ethnicity, age, and education. Further, it aims to characterize staff previous experiences in educational settings (professional experience) and turnover rates (how long staff have remained in their related position).

Aim 2— TO DOCUMENT PROGRAM-LEVEL CHANGES THAT OCCURRED DURING THE FIRST FULL YEAR OF IMPLEMENTATION OF THE POD INITIATIVE

This aim examines program-level changes such as staff professional development and staff beliefs that occurred during the PoD Initiative. The purpose of this aim is to determine if the Initiative was succeeding in increasing STEM training and/or staff beliefs in program sites.

Aim 3— TO EXAMINE RELATIONS BETWEEN STEM PROFESSIONAL DEVELOPMENT AND STAFF BELIEFS ABOUT STEM

This aim examines associations between professional development and staff beliefs about STEM. The purpose of this aim is to determine if increases in staff training are linked to relative gains in staff beliefs about STEM. A subset of analyses focus on the extent to which staff having prior experience implementing activities moderates the relation between professional development and staff beliefs.

Aim 4— TO EXAMINE LINKS BETWEEN STAFF BELIEFS AND IMPLEMENTATION OF STEM ACTIVITIES IN THE PROGRAMS

This aim examines associations between staff beliefs about STEM and program activities. The purpose of this aim is to determine if staff who endorse the value and importance of STEM learning also provide more engaging and challenging STEM activities at their afterschool sites.

Aim 5— TO EXAMINE LINKS AMONG STAFF BELIEFS, PROGRAM ACTIVITIES, AND GAINS IN STUDENT OUTCOMES

This aim examines the relations between: 1) staff beliefs and student outcomes; and 2) program activities and student outcomes. The purpose of this aim is to determine if staff beliefs about the value of STEM learning are linked to gains in student beliefs and motivation in the STEM domain. As part of this aim, we also ask if participating in more challenging and engaging STEM activities is linked to gains in student beliefs and motivation in the STEM domain.

Aim 6—TO EXAMINE RELATIONS AMONG THE OBSERVATIONS OF STEM ACTIVITIES, STAFF BELIEFS ABOUT STEM, PROGRAM ACTIVITIES, AND STUDENT OUTCOMES

This aim describes the observation data collected and examines relations between the Dimensions of Success observation ratings and: 1) staff beliefs about STEM; 2) program activities; and 3) student outcomes.

Section II. Methods and Measures

Selection of Program Sites

A total of 121 programs and 601 sites participated in the Power of Discovery Initiative in 2013-14.² From that list, UC Irvine invited sites from each of the five Regional Innovation Support Providers to participate in the PoD evaluation study. The initial goal was the recruitment of 25 sites per region. In cases where initially selected programs did not agree to participate in the study, the RISP sought out alternative participants. Irvine approached the target of 25 evaluation sites in three of the regions: 23 sites working with the Tech Museum of Innovation (TECH) in Northern California; and in Southern California, 29 sites from the OC STEM Initiative and 22 sites from San Diego County Office of Education (SDCOE). Alameda County Office of Education and the Gateways East Bay STEM Network (ACOE) with 8 sites and Sacramento County Office of Education (SCOE) with 14 sites had lower participation in the initiative. The final sample consisted of 96 program sites, with all regions represented by at least eight program sites.

Staff survey data were collected from 130 staff in fall 2013 and 97 staff in spring 2014. Within these groups, 49 staff completed surveys in both fall and spring.

Student survey data were collected from 2,957 students in fall 2013 and 2,337 students in spring 2014. Within these groups, 1,556 students completed surveys in both fall and spring.

As shown in Table 1, student and staff data were collected in all five regions being served by the RISPs, and observations were completed at a total of 52 sites in three regions.

Table 1							
Study Sites by RISP							
	Student Survey Sites	Student Surveys Completed	Staff Survey Sites	Staff Surveys Completed	Sites Completing STEM Activity Reports	Interview Sites (# of Interviews)	Observation Sites
ACOE	8	484	5	20	3	2 (4)	12
SCOE	14	556	8	16	4	0	0
TECH	23	1246	23	90	6	2 (4)	10
OC STEM	29	1964	24	35	26	6 (6)	30
SDCOE	22	1044	17	66	14	0	0
Totals	96	5294	77	227	53	10 (14)	52

² This is an approximate total number of programs and sites that participated in the PoD initiative, not the number sites in our study. This information was from the PoD website: http://powerofdiscovery.org/regional_innovation_support_providers. For each RISP, the number of programs and number of sites are listed. We summed the number of participating programs (121) and sites (601) from each RISP webpage to come up with the total number of sites in the initiative.

Table 2 summarizes the gender and grade level information for the student respondents.

Table 2 Gender and Grade Level, Student Respondents				
	PRE		POST	
	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
<u>Gender</u>				
Female	1,517	51%	1,188	51%
Male	1,440	49%	1,149	49%
<u>Grade Level</u>				
3 rd grade	613	21%	525	22%
4 th grade	774	26%	669	29%
5 th grade	719	24%	580	25%
6 th grade	447	15%	355	15%
7 th grade	240	8%	140	6%
8 th grade	151	5%	55	2%
9 th -12 th grade	13	.4%	13	.6%

Table 3 summarizes the gender and grade level information for the subsample of students (n = 1,556) who completed the student survey in both fall 2013 and spring 2014.

Table 3 Gender and Grade Level, Student Fall and Spring Respondents		
	<u>N</u>	<u>%</u>
<u>Gender</u>		
Female	805	52%
Male	751	48%
<u>Grade Level</u>		
3 rd grade	344	22%
4 th grade	446	29%
5 th grade	404	26%
6 th grade	213	14%
7 th grade	101	6%
8 th grade	40	3%
9 th -12 th grade	8	0.5%

MEASURES

The UC Irvine evaluation team utilized a multi-method, multi-respondent approach in its study of the *Power of Discovery: STEM²* Initiative. Collection of the study measures included the administration of online surveys to staff and students, the collection of staff reports on STEM activities implemented, and (for a subsample of sites) the on-site observations of STEM activities. In addition, staff interviews were conducted at a selected number of sites from the observation sub-sample.

Surveys

Pre- and post- surveys measuring program staff and student outcomes were administered using an online format during fall 2013 and spring 2014. Program staff online surveys were used to document the *demographic characteristics* and *educational background* and previous *experience implementing STEM-related activities* of program staff (Noam & Sneider, et. al., 2010). Staff also were asked to report on their *professional development experiences* and other supports they receive to improve their capacity to implement quality STEM activities (Vandell, et. al., 2008). In addition, staff surveys assessed changes in the *beliefs* and *attitudes* of program staff in the STEM domain and staff efficacy or sense of competency leading STEM activities (confidence in implementation).

Online surveys were also administered to students in the fall 2013 and again in spring 2014. These measures assessed student beliefs about STEM-related topics as well as broader youth outcomes. Students' *attitudes and beliefs* about STEM (interest and engagement in STEM learning, STEM career aspirations) were measured (Noam & Sneider, et. al., 2010, Tyler-Wood, Knezek, & Christensen, 2010), as well as *skill development* and *academic outcomes* (science, math and reading efficacy and work habits) and *positive behavior* (social competencies, misconduct).

STEM Activity Documentation Forms

STEM Activity documentation forms were used to document specific activities at program sites. Staff recorded the following information about each STEM activity that they implemented: (1) date and duration of the activity; (2) number of students participating in the activity; (3) name of activity and STEM content area addressed; and (4) four-point ratings of the level of student engagement, level of challenge, and overall assessment of success of the activity. Staff were provided with hard copy forms and instructions and prepaid pre-addressed envelopes for returning completed forms to UC Irvine.

Observations

An observation study was conducted at a subsample of 52 sites selected from the larger study sample in coordination with three RISPs (ACOE and TECH in Northern California, and OC STEM in Southern California). The Dimensions of Success (DoS) observation protocol—developed by the Program in Education, Afterschool & Resiliency (PEAR)—was used to assess the quality of STEM activities at all sites in the observation study sample. Six UC Irvine and 6 PEAR external evaluators completed DoS training and became certified by PEAR to use the DoS observation tool. DoS focuses on twelve dimensions of STEM activities under four main domains: (1) Features of Learning Environment; (2) Activity Engagement; (3) STEM Knowledge & Practices; and (4) Youth Development in STEM.

Interviews

Program site staff interviews were conducted by phone with site coordinators and site staff about their access to STEM curriculum and staff development resources, the nature of the STEM

component at their site, their experiences implementing quality STEM activities, as well as their experience receiving support from their corresponding RISP.

Sites selected for interviews had completed both staff and student surveys and STEM Activity Documentation forms as of February 2014. Interviews were carried out April-May 2014. After confirming the site selection with RISPs and respective program administrators, interviews were conducted by phone with site coordinators at the ten interview sites. In addition, a program staff that had completed documentation forms was interviewed at each of the four Northern California sites for a total of 14 interviews completed.

Section III. Findings

AIM 1— TO DOCUMENT THE CHARACTERISTICS OF THE AFTERSCHOOL WORKFORCE OF PARTICIPATING PROGRAMS

A total of 173 program staff completed an initial survey in late fall 2013 or early winter 2014. Staff responded to questions about their background (gender, age, ethnicity, education, professional experience) and their experiences in their current position. The initial survey indicated that the line staff was predominantly female (72%) and ethnically diverse (See Figure 2). Staff educational background varied: 1% had a M.A. degree, 25% had a B.A., and 16% an Associates (AA) degree. Overall, 54% reported to have attended “some college.” Many of the line staff were relatively young: 50% were between 18 and 25 years of age, 31% were between 26 and 35 years old.

I am just thankful that this initiative exists because it's been very helpful in shaping the way we run our activities and what we choose to do. Before, people were just pulling things from all over the place and there was no organization on how we did science activities in our afterschool program.

—Site Coordinator
Interview, April 2014

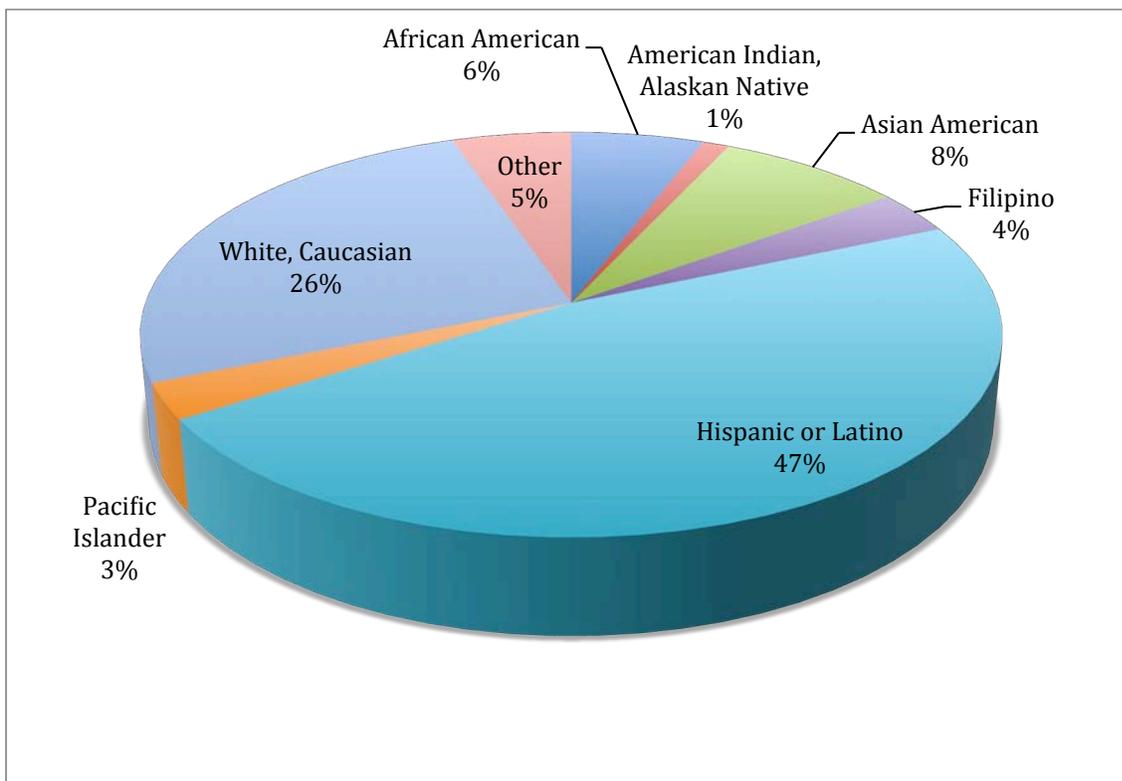


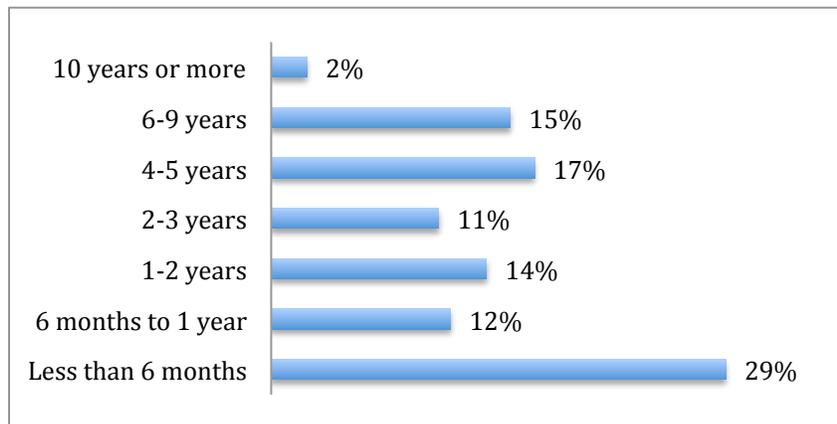
Figure 2. Race and Ethnicity of Program Staff

Professional Experience

Staff professional experience was highly varied: 65% have some experience in school settings (other than current position).

- 7% as a School Administrator
- 21% as a Classroom Teacher
- 23% as an Instructional Specialist (arts, ELL, P.E., special education)
- 51% as a Classroom Aide or TA
- 19% as School Administrative Staff
- 45% have been in their current position for 2 years or more (shown in Figure 3).

Figure 3
Staff Experience in Current Position



In conclusion, the above findings show considerable turnover of program staff, with more than half of the staff working at the program sites for less than two years. About a third of the workforce had worked at their respective sites for less than six months.

AIM 2— TO DOCUMENT PROGRAM-LEVEL CHANGES THAT OCCURRED DURING THE FIRST FULL YEAR OF IMPLEMENTATION OF THE POD INITIATIVE

This aim examines the changes in professional development during 2013-14, the first full year of the implementation of the RISP intervention, as reported by line staff. Significant changes in staff responses from pre to post surveys regarding staff professional development experiences provide evidence of the RISP intervention’s within these programs. We used within subject matched paired t-tests to examine statistical differences between staff responses in fall 2013 and spring 2014. This amounts to using data collected from staff who filled out both fall 2013 (pre) and spring 2014 (post) surveys (n = 49) and looking within those to determine a significant difference from pre to post for those staff members.

The first year we were connected to local resources that provide STEM for out-of-school time programs. That’s how I found out about [the Initiative] and all that they do. I also found out about different organizations in the Bay Area that offer afterschool training, kits, and activities. Then this year, once the workshops started, those were more like communities of practice. They would go over how to run a successful STEM activity and what you need to prepare for it.
 —Site Coordinator
 Interview, April 2014

Since people in the afterschool time aren’t necessarily trained in teaching or in these subjects [the PoD trainings] make it accessible. It’s great because it is like our staff is learning how to do these activities while our kids are also learning.
 —Site Coordinator
 Interview, April 2014

In terms of professional development changes, the amount of STEM training attended reported by staff significantly increased from fall 2013 to spring 2014. Discussions with teachers about STEM topics being taught in school also significantly increased. Staff reports of meetings with other afterschool staff to discuss STEM programming did not change significantly. Table 4 presents pre to post staff survey differences on professional development.

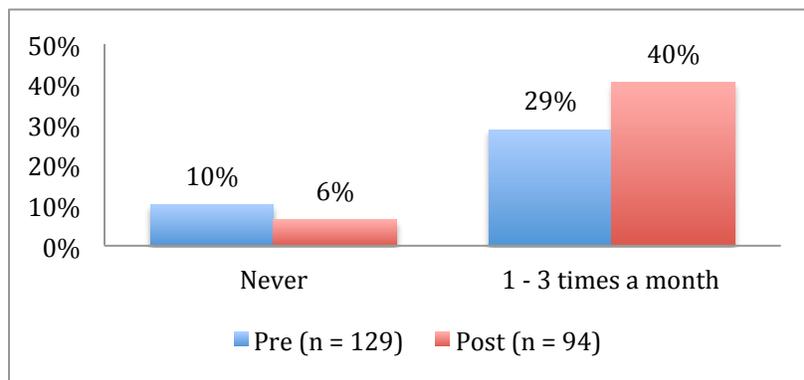
Table 4
 Pre to Post Staff Survey Differences, Professional Development

	Fall 2013			Spring 2014		<u>p-value of difference</u>
	<u>n</u>	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>	
<u>Professional Development</u>						
Frequency of meeting with other staff to discuss STEM programming	47	3.77	0.26	3.89	0.21	0.66
Amount of STEM-related training in the past year*	46	1.59	0.08	1.87	0.10	0.03
Frequency of discussions with classroom teachers about STEM concepts being taught in school*	46	2.63	0.27	3.33	0.24	0.02

Note: Asterisks indicate level of significance. † p≤.10, * p≤0.05, **p≤.01, ***p≤.001

Figure 4 illustrates the changes in staff meetings about STEM subjects. There was a substantial gain in the proportion of programs that had monthly staff meetings about STEM activities (from 29% to 40%) and a decrease from 10% to 6% in their reporting of “Never discussing STEM at staff meetings.”

Figure 4
Frequency of Staff Meetings About STEM



Staff also reported changes in STEM outreach to parents in other aspects. Within subject matched paired t-tests were used to examine statistical differences between staff responses in fall 2013 and spring 2014. In terms of program offerings, the frequency of staff members’ discussions with parents about STEM activities significantly increased. Further, staff reported a significant increase in hosting events or meetings for parents such as science fairs and/or family math nights. Table 5 presents pre to post staff survey differences on program offerings.

We have a showcase for after school night in the library. I have science activities on the tables and pictures of what we’ve done. I encourage the students to invite their parents and teach them one of the experiments that we’ve done.

—Site Coordinator
Interview, April 2014

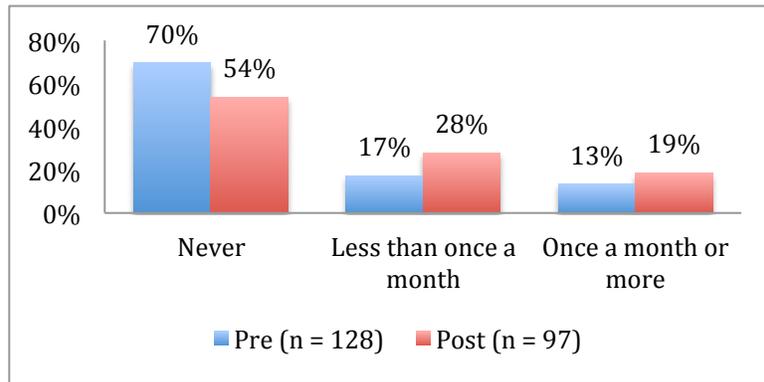
Table 5
Pre to Post Staff Survey Differences, Program Offerings

	Pre-Participation			Post-Participation		p-value of difference
	n	Mean	SD	Mean	SD	
Frequency of discussions with parents about STEM activities*	48	2.27	0.23	2.85	0.20	0.03
Frequency of staff hosting STEM related events or meetings for parents**	47	1.32	0.10	1.79	0.15	0.00

Note: Asterisks indicate level of significance. † p≤.10, * p≤0.05, **p≤.01, ***p≤.001

To further illustrate this change, Figure 5 shows a graphical representation of the breakdown of categorical responses given by staff members indicating increases in STEM events involving parents from fall 2013 to spring 2014.

Figure 5
STEM-Related Events with Parents



AIM 3— TO EXAMINE RELATIONS BETWEEN PROFESSIONAL DEVELOPMENT AND STAFF BELIEFS

A. RELATIONS BETWEEN PROFESSIONAL DEVELOPMENT AND STAFF BELIEFS

The third aim of this study is to examine the relations between professional development and staff beliefs about STEM and their perceived efficacy in implementing STEM activities.

Regression analyses were conducted to test these relations.

The independent variables used in the regression models include: staff attending training during the past academic year (both general and STEM-related), the frequency of staff meetings (to discuss both program issues and STEM programming), and the frequency of staff discussing with teachers STEM concepts being taught in school. The amount of training (both general and STEM-related) that staff attended in the past academic year was treated as a continuous variable ranging from 1.00 to 6.00 with each unit representing a category of training sessions attended in ascending order.³ How often staff met with other staff to discuss program issues and STEM programming was also treated as a continuous variable ranging from 1.00 to 7.00, with each unit representing a category of meeting frequency in

I think that the [OC Stem seminar] was really helpful because we were shown how to lead activities we have done from the district trainings, but it is taught in a more hands-on way, easier to deliver, and more fun for the students.

—Site Coordinator
Interview, April 2014

³ A score of 1 corresponds to 0 sessions (none), 2 corresponds to 1 to 4 sessions, 3 corresponds to 5 to 9 sessions, 4 corresponds to 10 to 14 sessions, 5 corresponds to 15 to 19 sessions, and 6 corresponds to 20 sessions or more.

ascending order.⁴ Lastly, staff reporting on meeting with teachers to discuss STEM concepts being taught in school was a continuous variable ranging from 1.00 to 6.00, with each unit corresponding to frequency in ascending order. The categorical scale for this variable matches the categories for staff meetings. The dependent variable used in analyses, staff beliefs and efficacy scores, are continuous variable ranging from 1.00 to 5.00 and are derived as aggregate means of all questions pertaining to staff beliefs about STEM and efficacy in implementing STEM activities. All variables were taken from scores on the staff post-participating survey. Staff gender and ethnicity were the two control variables that were used in the regression models.

Significant results for the regression analyses are summarized in Table 6 below. In summary, staff members who attended training in general and training related to STEM activities were associated with staff reporting having higher beliefs about the importance of STEM activities. Specifically, a one standard deviation increase in staff attending training in the past academic year was associated with a 0.34 standard deviation increase in reported beliefs about STEM. A one standard deviation increase in staff attending STEM-related training in the past academic year was associated with staff having a 0.29 standard deviation increase in beliefs about STEM. More frequent meetings with other staff to discuss program issues and to discuss STEM programming was also significantly associated with staff having stronger beliefs about STEM. A one standard deviation increase in staff members meeting to discuss program issues was associated with a 0.29 standard deviation increase in staff beliefs about STEM and similarly, a one standard deviation increase in staff meeting with one another to discuss STEM programming was associated with a 0.25 standard deviation increase in staff beliefs about STEM.

In terms of staff efficacy for implementing STEM activities, staff members who attended training were associated with having greater efficacy. A one standard deviation increase in staff attending training in the past academic year was significantly associated with a 0.31 standard deviation increase in staff-reported efficacy for implementing STEM activities. More frequent meetings with other staff to discuss program issues and to discuss STEM programming was also associated with greater efficacy. Specifically, a one standard deviation increase in the frequency of staff meeting with one another to discuss program issues was associated with a 0.29 standard deviation increase in staff efficacy. A one standard deviation increase in staff meetings to discuss STEM programming was associated with a 0.37 standard deviation increase in staff efficacy for implementing STEM activities. Lastly, a one standard deviation increase in staff members discussing STEM concepts being taught in school with teachers was significantly associated with a 0.27 standard deviation increase in staff-reported efficacy.

When we got trained for the TECH grant, I introduced it to my two program leaders who are in charge of the 4th and 5th graders. We [now] spend extra time prepping the lessons and researching additional resources.

—Site Coordinator
Interview, May 2014

⁴ A score of 1 corresponds to 0 (ever), 2 corresponds to less than once a month, 3 corresponds to once a month, 4 corresponds to 2 to 3 times a month, 5 corresponds to once a week, 6 corresponds to 2 to 3 times per week, and 7 corresponds to 4 to 5 times per week.

Table 6
Associations Between Staff Training and STEM Beliefs

<u>Predictor</u>	<u>Outcome</u>	<u>Beta</u>
	Beliefs	
Staff attending training during the past academic year		0.34***
Staff attending training related to STEM activities		0.29*
Frequency of staff meetings to discuss program issues		0.29*
Frequency of staff meetings to discuss STEM programming		0.25*
	Efficacy	
Staff attending training during the past academic year		0.31**
Frequency of staff meetings to discuss program issues		0.29*
Frequency of staff meetings to discuss STEM programming		0.37**
How often staff discussed STEM concepts being taught in school with teachers		0.27*

Note: Asterisks indicate level of significance. † p≤.10,* p≤0.05, **p≤.01, ***p≤.001

B. DIFFERENCES IN THE RELATIONS BETWEEN PROFESSIONAL DEVELOPMENT AND STAFF BELIEFS BY STAFF PREVIOUS EXPERIENCE

Additional analyses were conducted to examine whether the relations between professional development and staff beliefs varied by staff previous experiences. Analyses examined various forms of staff previous experiences including whether staff have experience working in a school setting, whether staff had been working at their respective site for more than two year, and whether staff had previous experience implementing STEM activities. Of the analyses, only significant findings are reported on, which included the analysis using whether staff had experience implementing STEM activities.

Analyses used an interaction term to identify differences in the associations between professional developments and staff beliefs. The interaction term consisted of a dichotomous variable indicating whether or not staff had experience implementing STEM activities and each of the professional development variables: staff attending training during the past academic year (both general and STEM-related), the frequency of staff meetings (to discuss both program issues and STEM programming), and the frequency of staff discussing with teachers STEM concepts being taught in school. One significant relationship was found between the frequency of staff discussions with teachers and staff efficacy for implementing STEM activities. Significant results for the regression analyses are summarized in Table 7 below. In summary, staff that reported frequent discussions with classroom teachers about STEM concepts being taught in school experienced a 0.73 standard deviation increase in efficacy beliefs by the end of the initiative. However, this effect is moderated by whether staff had previous experience implementing STEM activities. Staff that reported previous STEM experience did not experience a significant change in efficacy beliefs (0.73 + -0.77 = -0.04). In conclusion, staff that had frequent discussions with teachers about STEM concepts being taught in school experienced increases in their efficacy for implementing STEM activities; however, these increases were not experienced by staff who had previous experience implementing STEM activities,

Table 7
Moderation Between Staff Discussions with Teachers and Efficacy

<u>Predictor</u>	<u>Outcome</u>	<u>Beta</u>
	Efficacy	
Frequency of staff meetings to discuss STEM programming		0.73*
Previous STEM experience		0.14
Frequency of staff meetings to discuss STEM programming X Previous STEM experience		-0.77*

Note: Asterisks indicate level of significance. † p≤.10, * p≤0.05, **p≤.01, ***p≤.001

AIM 4— TO EXAMINE LINKS BETWEEN STAFF BELIEFS AND IMPLEMENTATION OF STEM ACTIVITIES IN THE PROGRAMS

The fourth aim of this study is to examine relations between staff beliefs about STEM and their perceived efficacy in implementing STEM activities and program activities (e.g., how the activity went overall, how engaged the students were, and the level of challenge of the activity). In addressing this aim, we first examine the characteristics of the program activities as reported through activity forms submitted by staff members in the participating programs.

A. PROGRAM STEM ACTIVITIES

A total of 84 staff submitted *STEM Activity Documentation Forms* in which they reported the implementation of 2,457 different STEM activities. The activity forms included the following information about *each* activity: its duration, STEM content area(s), number of participating students, student grade level, level of student engagement, level of challenge to the students, and overall success of the activity.

The total number of activities reported by an individual staff member ranged from 1 to 120 and the average number of activities reported by each staff was 51.

Staff reported that the number of students participating in a particular activity ranged from 1 to 130; the average number of participating students per activity was 28. The duration of the activities ranged from 15 minutes to 2 hours. Most of the activities (n = 1,702, 69%) lasted 30 to 59 minutes. About 273 (about 11%) of the activities lasted less than 30 minutes, and 462 (about 19%) of the activities lasted longer than one hour.

Student grade level was reported for all of the activities. Most activities were reported by staff to include students at multiple grade levels. A total of 67,576 youth were reported to participate in these activities. The majority of activities included students in grades three, four, and five (18%, 22%, and 19% respectively).

The Initiative is there to expand the amount of time kids have exposure to STEM and I know that during the school day, there is a lot going on and there is more flexibility in the out-of-school time in terms of what we can do, when we can do it, and how often we can do it.

—Site Coordinator
Interview, April 2014

Of the documented activities, 2,398 (out of 2,457) identified a specific STEM focus (Science, Technology, Engineering, Mathematics). Of the activities reported, the majority of activities (1,539 activities, 63%) focused on one STEM area only. About 25% (619 activities) of the activities focused on two STEM areas, about 6% (144 activities) included three areas, and about 4% (96 activities) included all four STEM areas in the activity. Of the four STEM areas, science was most often the focus of the activity (57% of all activities).

Staff reported that the STEM activities went well. Over 91% of the activities (n = 2,197) went “very well” (53%) or “mostly well” (38%). Only 1% of the activities (n = 15) were reported by staff to go “not at all well”.

It is very good that they learn a lot of new concepts without feeling that science is very difficult. So they are exposed to science, engineering, and mathematics in a fun way. For those who are performing below grade level, which are 95% of my kids, this is an opportunity to learn in different ways.

—Site Coordinator
Interview, April 2014

For 2,457 of the documented STEM activities, staff rated how challenging the activity was for the students. The majority of activities (82%) were reported by staff to be either “very challenging” for the students (n = 560, 23%) or “somewhat challenging” (n = 1,425, 59%). About 16% (n = 382) of the activities were considered “not at all challenging” and 55 of the activities (2%) were reported by staff as “too challenging”.

Staff also rated students’ level of engagement in the activities. For the majority of activities (n = 2,242, 92%), students were either “very engaged” (56%) or “mostly engaged” (36%). Students were reported to be “not at all engaged” for less than 1% of the activities.

What we are trying to do is to expand STEM learning using science, math, technology, engineering, and introduce that into the afterschool program in a sort of different manner from the school day. So we would argue that it gets kids to be introduced to and get excited about STEM.

—Site Coordinator
Interview, April 2014

An examination of the correlations between staff reported overall activity, challenge, and student engagement measures shows that there was not a significant correlation between the level of staff reported challenge and students’ level of engagement. However, students’ level of engagement with an activity was significantly and positively correlated with the overall activity measure (0.61, $p < 0.001$). For activities in which students were engaged, the staff reported overall activity measure increased. Lastly, activity challenge was significantly and negatively correlated with the overall activity measure (-0.10, $p < 0.001$). For activities that were “too challenging” staff reported lower levels of overall quality of the activity, on average.

B. ASSOCIATIONS BETWEEN STAFF BELIEFS AND PROGRAM ACTIVITIES

Simple linear regression analysis was conducted to examine the associations between staff beliefs about the value of STEM activities and the implementation of STEM activities as reported on the STEM Activity Documentation Forms. Two staff measures of staff beliefs were

examined as predictors in the analyses: staff-reported beliefs about STEM and staff-reported efficacy in implementing STEM activities. The staff beliefs and efficacy scores are continuous variables, ranging from 1.00 to 5.00. All variables were taken from scores on the staff post-participation survey. For each variable, an aggregate mean score for that staff’s site was created to use in analyses because only site-level identifiers were consistent between the staff and activity forms submitted. The dependent variables used in the analyses were the three measures: overall, challenge of the activity, and student engagement in the activity. All three variables were treated as continuous ranging from 1.00 to 4.00 (the scales for which are discuss above). The measures of activity quality were also site-level mean variables in the analyses. All variables were standardized prior to regression for across variable comparisons.

Significant results for the regression analyses are summarized in the table below. Stronger staff beliefs about the importance and benefit of STEM activities were significantly associated with higher overall activity quality and higher levels of student engagement in the implemented activities. Specifically, a one standard deviation increase in staff beliefs about STEM was associated with a 0.26 standard deviation increase in overall activity quality. A one standard deviation increase in staff beliefs was also associated with a 0.31 standard deviation increase in student engagement in the activity. Lastly, greater staff efficacy for implementing STEM activities was significantly associated with higher levels of student engagement. A one standard deviation increase in staff-reported efficacy was associated with a 0.25 standard deviation increase in student engagement in the activity.

Table 8
Associations of Staff Beliefs about STEM on Student Post-Participation Outcome Scores

<u>Predictor</u>	<u>Outcome</u>	<u>Beta</u>
Staff Beliefs about STEM	Overall Activity Quality	0.26*
Staff Beliefs about STEM	Student Engagement in Activity	0.31***
Staff Efficacy for STEM	Student Engagement in Activity	0.25†

Note: † p≤.10, * p≤0.05, **p≤.01, ***p≤.001 = statistically significant relationship between predictor and outcome score

AIM 5—TO EXAMINE LINKS AMONG STAFF BELIEFS, PROGRAM ACTIVITIES, AND GAINS IN STUDENT OUTCOMES

The fifth aim of this study is to examine the relations 1) between staff STEM-related beliefs and student outcomes and 2) between STEM program activities and student outcomes. Regression analyses were conducted to examine associations between 1) staff beliefs and efficacy and students’ post-participation outcome scores and, 2) program activities and students’ post-participation outcome scores. The staff belief and efficacy scores were used as a predictor variable and is continuous ranging from 1.00 to 5.00. These scores were taken from scores on the staff post-participation survey. Staff-reported beliefs were used

It is good to get them to talk and think about science as a career because many of them do not think as science as something they can do. [When engaged in STEM activities] they can think, “Oh, this is something I can do.”
—Site Staff
Interview, April 2014

When we do design and engineering challenges we are teaching them a lot of skills that they lack. When they work in a group they have to learn how to solve problems, and how to deal with a conflict. We are giving them a chance to practice these skills since they don't have a lot of time to practice them in the school day.

—Site Coordinator
Interview, April 2014

as a site-level means because only site-level identifiers were used to match students to staff members at their sites. In the analyses, the predictor scores for each staff-reported measure was the aggregate mean score for that staff member's site. Two control variables were also used in the regression model: student gender and students' pre-participation student outcome scores.

The program offering measures, such as the activity challenge, are continuous variables ranging from 1.00 to 4.00. Time on STEM was also treated as a continuous variable in analyses ranging from 1.00 to 8.00 with each unit representing a category of time in ascending order.⁵ Staff-reported discussions with teachers about STEM

concepts being taught in school is also a variable that was treated as continue variables ranging from 1.00 to 6.00, with each unit representing a greater amount of meetings between staff and teachers.⁶ These predictor variables were also site-level means because site-level identifiers were used to match program-offering variables to students at each site. In the analyses, the predictor scores for each activity quality measures were the aggregate mean score for that student's site. Two control variables were also used in the regression model: student gender and students' pre-participation student outcome scores.

Significant results for the regression analyses are summarized in Table 9 below. Controlling for gender and pre-participation scores, stronger staff beliefs about the importance and benefit of STEM activities for students was significantly related to higher post-participation outcome scores in math efficacy. A one standard deviation increase in staff-reported beliefs was associated with a 0.06 standard deviation increase in students' math efficacy. There was a significant association found between the level of staff-reported challenge presented in the activity and various student outcomes (work habits, reading efficacy, math efficacy, misconduct, science interest, and science career). A one standard deviation increase in the staff-report level of challenge presented in the activity was significantly associated with a 0.08 standard deviation increase in students' post participation work habits ($n = 963$), a 0.06 standard deviation increase in students' post participation reading efficacy ($n = 956$), a 0.07 standard deviation increase in students' post participation math efficacy ($n = 956$), a 0.06 standard deviation increase in students' post participation interest in science ($n = 962$), a 0.07 standard deviation increase in students' view of

I think that it is about creating new opportunities for the new work force that's going to be present in these children's lives when they are adults, and that makes sense to me. It's giving them tools that they can actually use to get jobs in the real world.

—Site Staff
Interview, April 2014

⁵ A score of 1 corresponds to None, 2 corresponds to 15-30 minutes, 3 corresponds to 30-60 minutes, 4 corresponds to 1-2 hours, 5 corresponds to 2-3 hours, 6 corresponds to 3-5 hours, 7 corresponds to 5-10 hours, and 8 corresponds to 10 or more hours.

⁶ A score of 1 corresponds to 0 (ever), 2 corresponds to less than once a month, 3 corresponds to once a month, 4 corresponds to 2 to 3 times a month, 5 corresponds to once a week, 6 corresponds to 2 to 3 times per week, and 7 corresponds to 4 to 5 times per week.

pursuing a career related to science ($n = 954$), and a 0.09 standard deviation decrease in students' misconduct ($n = 937$). Greater amount of time spent on STEM activities was significantly related to higher scores in math efficacy. Specifically, a one standard deviation increase in time spent per week implementing STEM activities was associated with a 0.11 standard deviation increase in students' post participation math efficacy ($n = 842$). A one standard deviation increase in staff meeting with teachers to discuss STEM concepts being taught in school was significantly associated with a 0.12 standard deviation increase post-participation outcome scores in science efficacy ($n = 842$) and a 0.09 standard deviation increase in student-reported likelihood of a successful future ($n = 831$). Lastly, a one standard deviation increase in staff members meeting with parents to discuss STEM activities in the program was significantly associated with a 0.08 standard deviation increase in students' post participation math efficacy ($n = 842$) and a 0.12 standard deviation increase in students' post participation science efficacy ($n = 842$).

Table 9
Associations Between 1) Staff Beliefs and Student Post-Participation Outcome Scores and, 2) Program Activities and Student Post-Participation Outcome Scores

	<u>Student Outcome</u>	<u>Beta</u>
<u>Staff Beliefs</u>		
Staff Beliefs about STEM	Math Efficacy	0.06*
<u>Program Activities</u>		
Activity Challenge	Work Habits	0.08**
	Reading Efficacy	0.06*
	Math Efficacy	0.07**
	Science Interest	0.06*
	Science Career	0.07*
	Misconduct	-0.09***
Time Spent on STEM	Math Efficacy	0.11***
Staff Discussions with Teachers	Science Efficacy	0.12***
	Likelihood of Future Success	0.09**
Staff Discussions with Parents	Math Efficacy	0.08*
	Science Efficacy	0.12**

$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

AIM 6—TO EXAMINE RELATIONS AMONG THE OBSERVATIONS OF STEM ACTIVITIES, STAFF BELIEFS ABOUT STEM, STAFF REPORTS OF PROGRAM ACTIVITIES, AND STUDENT OUTCOMES

A. OBSERVATIONS

With supplemental funding from the Noyce and Bechtel Foundations, observations of the quality of STEM programming were collected at 52 sites (30 Southern California and 22 Northern California sites) using the Dimensions of Success (DoS) observation tool. The DoS is an observation system that was developed by the Program in Education, Afterschool and Resiliency

(PEAR) in partnership with Educational Testing Service (ETS), Project Liftoff, and other practitioners. The DoS rates 12 aspects of the quality of STEM activities in out-of-school programs, using four-point ratings. The 12 dimensions are organized around four overarching themes: feature of the learning environment, activity engagement, STEM knowledge and practices, and youth development in STEM. The 12 dimensions are motivated by the National Science Foundation's evaluation framework (Friedman et al, 2008) and the six strands for learning science in informal environments published by the National Research Council (2009).

Twelve trained and certified external observers conducted two-day observations at the 52 sites, for a total of 206 observations. Descriptive statistics are presented in Table 10. As shown, Space Utilization and Materials received the highest ratings (M = 3.36 and 3.30, respectively), and Youth Voice and Inquiry received the lowest ratings (M = 2.17 and 2.22, respectively)⁷.

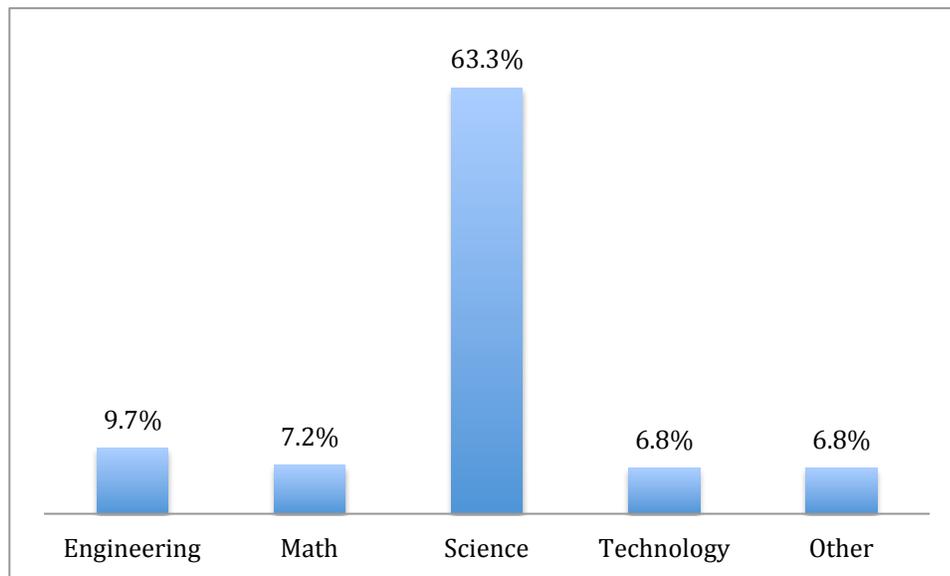
Table 10
Descriptive Statistics, Dimensions of Success Observations by Site

	<u># of Valid Obs.</u>	<u>Mean</u>	<u>SD</u>	<u>Range</u>
Average # of students per site	52	18		7-32
<u>Dimensions of Success</u>				
Materials	52	3.30	0.64	1.00-4.00
Space Utilization	52	3.36	0.66	2.00-4.00
Participation	52	3.16	0.54	2.00-4.00
Purposeful Activities	52	2.89	0.58	1.50-4.00
Engagement with STEM	52	2.75	0.64	1.50-4.00
STEM Content Learning	52	2.40	0.57	1.00-3.50
Inquiry	52	2.32	0.79	1.00-4.00
Reflection	52	2.22	0.63	1.00-3.50
Relationships	52	3.28	0.74	1.50-4.00
Relevance	52	2.27	0.79	1.00-4.00
Youth Voice	52	2.17	0.73	1.00-4.00

Science was the most commonly observed (63%) STEM activity, with Engineering, Math, and Technology foci observed 9.7%, 7.2%, and 6.8% respectively. About 6.8% of the time observers identified another (noted as “Other”) area of focus and 13 activities (or 6.3%) were not noted as having a focus. The percentage of STEM area foci observed in the rated activities is summarized in Figure 6 below.

⁷ For a related study using the data collected at these study sites with the Dimensions of Success Observation Tool, see, *Internal and External Observer Use of the Dimensions of Success (DoS) Observation Tool: A Collaborative Study in Northern and Southern California*, conducted by PEAR at the Harvard University and the School of Education at University of California, Irvine (Noam, G. and Vandell, D. L., 2014).

Figure 6
Percentage of STEM Area Focus in Activities Observed



Vignettes of STEM Activities

Qualitative observations collected at the same time as the Dimensions of Success observations help to describe the DoS dimensions in more detail. The two observations reproduced in Box 1 and Box 2 serve to illustrate practices rated highly along the 12 Dimensions of Success. The third vignette, Box 3, provides an example of an activity that was not rated highly—particularly along the dimensions of Purposeful Activities, Engagement with STEM, STEM Content Learning, Inquiry, Reflection, and Relationships—and points to the need for staff to have the appropriate training and support in order to lead activities that maximize STEM learning opportunities for youth in afterschool programs.

BOX 1. STEM ACTIVITY VIGNETTE

Engineering—Building a Ski Jump

The challenge written on the white board states: “Design a ski jump that makes your marble jump into a can without bouncing on the floor. How far can the marble jump and still land in a can?” At 4:30 in the afternoon twenty-four fifth graders, attending the afterschool program run by a community based organization at their school site, are in a classroom bungalow eager to meet the challenge. Also written on the board are the required features (hills, loops; valleys; spirals; gaps) and building criteria (slopes, length of slope, and stability) for constructing their ski jumps.

Students are very excited about the activity. They listen attentively to the adult facilitator as she gives some pointers and then lets each group collect their materials: tracks foam tubes, clothespins, pipe cleaners, adhesive tape, and rulers. There are plenty of supplies for each of the five groups. Books, tables and chairs are used to prop up different sections of the ski jump that students immediately begin to build. The noise level in the room is loud as students are enthusiastically talking amongst each other, figuring out how to get the marble to come down a slope, jump a gap, go through a loop and make it into the final cup.

Two facilitators circulate around the room stopping at each of the groups of five to six students providing them with further orientation and prompting them to think of solutions to the design problems they discover as they test their slopes. “Where is the marble jumping off?” a facilitator asks a group whose marble shoots off before completing the slope. “Ok you guys, you need tape right here,” she points to a part in the structure that needs stabilizing. The facilitator further pushes students to figure out what is not working with their jump and offers some suggestions:

“So what did the marble do? Did [your fix] stabilize like a bridge? Maybe get a chair and books to stabilize.” The students excitedly jump into action, “Oh get a table!” one group member exclaims. A girl runs to grab a table and puts it under the track. A boy helps her move the table and position it. The other two boys assist with attaching the rest of the track.

Another group of students engage in this problem solving process: “How come the marble goes slow?” one student asks. Another suggests: “Don’t have it go too fast.” The students continue to work to make adjustments to their ski slope constructions based on their tests and observations. They improvise solutions, stabilizing strips of track with books, securing their final cups with tape to stay steady and catch the marble. Each group designs a unique ski jump. One group, through trial and error, finally is able to get the marble to make it across a jump into the cup. When the marble makes it the whole group yells out with excitement at their accomplishment. “YAY!”

Once all groups have had a chance to construct their loop, gap and test their model, the facilitator starts to debrief the activity. “Who was able to make it through the gap?” she asks. All five groups confirm that they were able to make the jump. “Did everybody’s marble make it to the end?” Three groups raise their hands excitedly and exclaim, “Yay!” in unison. “What worked and what didn’t; work?” the facilitator further prods. Students call out answers describing the different ways they solved the problems they faced in making their jump work: “We added volume,” “Used pipe cleaner to make it straight.” The facilitator questions the group to clarify what they mean: “Make it...?” Students finish his sentence in unison, “Stable!” As the activity group reflection comes to a close at 5:00 pm, a boy turns to his partner and says, “That was fun!”

BOX 2. STEM ACTIVITY VIGNETTE

Science—Making Lava Lamps

A young African American adult male speaks with clarity and confidence to eighteen fourth and fifth grade students in an afterschool program classroom on a rainy winter afternoon. The diverse group of African American, Asian, Latino and White students are sitting excitedly at five tables arranged so that they can work collaboratively. The facilitator announces, “For today’s lesson we are going to go over Lava Lamps.” Several students eagerly respond to his question, “What is a Lava Lamp?”: “A Lava Lamp changes color and shapes.” “Something that changes colors and has lava.” “Good answers,” he confirms and continues. “First things first, what you need is water and food coloring.” He instructs them to put the food dye in the water and asks, “Why does the food color mix with water?” One student offers, “Because food coloring has coloring and when you drop it in water, because it’s clear, it turns that color.”

Students are highly engaged and the facilitator takes care to call on all students to contribute to the discussion, he allows students to ask questions and writes the group’s hypotheses, observations and conclusions on the board throughout the hour-long activity. Although the facilitator holds lesson plan notes for reference, he addresses the students in a natural tone and is flexible in responding their interests, maximizing learning opportunities while pacing the activity allowing time for students to reflect on their experience and learning.

“Raise your hand if you know what the word density means?” he asks. Several students raise their hand. “It means that you identify something,” one boy ventures to answer. “Not exactly, density is... [the facilitator speaks as he writes the word on the board and spells it out] d-e-n-s-i-t-y is about how if something is dense it goes to the top; if it is less dense it goes to the bottom. This is the case with water and oil. Water weighs more than oil so water goes to bottom.” He draws an illustration of this process on the on board, and points out: “Water is down here, oil up here.” He poses a second question: “Do you think the food color has the same density as water? Water and food color are strangers that became best friends, Sarah can you can tell why?” The student responds, “Because if they are different they do not mix.” “Right if it was less dense it would be at top,” the facilitator confirms. He then explains how this is an example of two substances that are “immiscible.”

He continues to explain that they are going to use the “Scientific Method.” “The first part is the hypothesis, what you think is going to happen? [...] What is going to happen when each person puts a piece of Alka-Seltzer [into the oil and water mix]?” The facilitator asks each table for their hypotheses, and students report out: “It’s going to form blobs,” “It’s going to blow up.” He writes them into a table on the white board with the headings “Hypothesis; Conclusion; Observation; Cool/Weird.” Also written are the following “Science Words”, “Immiscible, Density, Carbon Dioxide, Chemicals, Soluble, Dissolve, React, Vegetable” to which reference is made during the ongoing facilitated discussion. Students take turns pouring the oil into the cylinder, observe the reaction created when dropping an Alka-Seltzer tablet into the mixture, and loudly proclaim their observations: “It’s bubbling up!,” “It’s going to explode!” One student announces: “This is cool, this should be on Facebook!”

The facilitator calls the group to attention, “Let’s debrief. What did you learn from this?” A student responds, “That oil can not mix with water.” “Andrew learned, because of what word?” he points to the board, “Density, because of density oil and water can not mix.” “Kate what did you learn?” “New science vocabulary words,” Kate shares. And when prompted to provide her “favorite” science word she confidently responds, “Density.” “What is density?” the facilitator persists, “So why do some things go up and stay down? Are we dense?” A boy answers, “Yes, if we didn’t have gravity we would be in space now.” “Pretty much,” the facilitator acknowledges and further illustrates the point, “Oxygen weighs more than helium. Helium weighs nothing. You have form and that pushes you down. Helium goes up.” He does one final check for comprehension, “Immiscible, what does that mean?” A student responds: “It can’t mix with some other chemicals.” “Very good, very much correct!” the facilitator proudly affirms.

BOX 3. STEM ACTIVITY VIGNETTE

Technology—Digital Recording & Editing

The young male staff leading a Technology activity is new to this community-based organization offering afterschool programming at an elementary school site in an urban immigrant community. He arrives early to set up laptops for students to use in a digital recording and sound editing activity. At 3:30 in the afternoon, twenty 5th and 6th grade students rumbustiously file into the spacious classroom, after having had their afternoon snack, and sit in groups of five at four sets of desks. The majority of participants are Latino and some students are code switching between Spanish and English when speaking with each other. The facilitator is a soft-spoken native English speaker and has a hard time getting students to settle down and listen.

Once they are all seated at their group tables, he quickly goes over the activity: first they are to interview him and record the interview as a demonstration. They will then record a mock interview within their group and edit the digital recording using a program on the laptop placed on each groups' work table. He tries to get students' to start: "Shhh..., ok you guys you're gonna write the questions...Let's go you guys, we got to be done in 4 minutes...Write as many questions as you can!" The participation is uneven within each group as only half of the students are able to focus and write down random questions on a sheet of paper to ask the facilitator with the limited guidance provided. One group of girls write, "Do you like Christmas? Do you like decorating your stockings? Do you like to bake?" Another group of boys write, "Do you like basket ball? How many games have you won?"

The facilitator walks around and checks in with students, "Do you need more time?" Students do not respond, but just keep talking among themselves. At one table students are playing around and making loud noises, at another two girls are hugging each other, a boy wanders to the door and looks outside, another boy bounces a ball on the table. Fifteen minutes into the activity the facilitator tries to get control of the group and counts out loud: "1, 2, 3, 4, 5..." The students settle somewhat and he points to a group with questions written on their paper, "This group is going to be the lead, they are going to ask me questions about my family. You guys are going to record the conversation. When you are all paying attention you are going to press this red button right here." Interrupted by students talking in the background, he calls out, "Everybody be quiet!" in another effort to get the students to gather around a single laptop. "We are about to record right now." He encourages the selected students to begin their interview, "Let's ask a question about family." The student asks, "Do you have a sister?" and he responds, "No, I do not, my family is all boys, I am the last one." Most students are quiet and are gathered around engaged and listening." A student asks the next questions but some students continue to chat in the background. He stops the interview, "Ok that's enough. Now this will prove to me that you guys were talking. You know why I asked you guys to be quiet? Because if we were being serious this is what I recorded." He plays back the recording and the students laugh out loud when hearing their recorded voices making random comments. The facilitator points out, "If this was a radio station then they would say, 'Who is this guy?'"

Students are then instructed to work in their groups, recording and editing a mock interview, but only one or two students per group are able to be active in the process of carrying out the assigned tasks on a single laptop. Half an hour into the activity some of the students are getting out of their seats and talking amongst themselves, but not about the activity. At one table, a girl sits directly in front of the laptop editing and appears very focused on learning how to use the sound editing software, while others in the group are just listening to the recording with amusement, but without any interest in the editing process. The rest of the group is goofing around, and the facilitator goes over and tells them to "stop it." He calls the entire group all to a computer again, "What did you guys do wrong?" One student tries to respond, "Cause they didn't do it right..." Students play back sound in high speed and students laugh. "Stop it!" the facilitator reiterates to no avail as he loses the attention of most of the students again. During the last 15 minutes only six students are working on a computer, the rest are roaming around the room, playing and totally disengaged with the activity.

Although there is a clear goal of learning how to use digital software to record and edit sound by carrying out a mock radio interview, the activity is not organized in a way that allows all students to participate. The facilitator tries to connect the experience to a real world context of radio broadcasting but his efforts to make it relevant are lost due to a poorly structured activity, limited laptops and resulting low participation. Because students are disengaged, too much time is dedicated to managing students' disruptive behaviors resulting in many missed opportunities for guided STEM learning and technology skill building to occur.

B. CORRELATIONS BETWEEN OBSERVER RATINGS AND STAFF BELIEFS

Staff surveys were obtained at 36 of the sites at which observations were conducted. Pearson correlation coefficients were then used to examine associations between observed quality and staff beliefs about STEM. For these analyses, site-level staff beliefs were created as the mean score for all staff reports at the site. Site-level observation data means were created by calculating the aggregate mean score of ratings under each dimension per site. The largest correlations were between staff beliefs about the importance of STEM learning and observed Purposeful Activities ($r = 0.24$), Youth Voice ($r = 0.21$), and Relationships ($r = 0.17$). These suggestive correlations did not reach statistical significance, likely (in part) because of the small sample ($n = 36$ sites).

C. CORRELATIONS BETWEEN OBSERVER RATINGS AND STAFF REPORTS OF PROGRAM ACTIVITIES

Pearson correlations were also conducted to examine relations between the DoS observations and the staff reports of student engagement obtained from the Activity Documentation forms. These data were available at 29 program sites. Staff-reports on overall activity quality and student engagement were the mean scores for all staff reports at the site. Site-level observation data means were created by calculating the aggregate mean score of ratings under each dimension per site. The correlations between staff reports of overall activity quality and external observer ratings of Relationships ($r = 0.33$) and Reflection ($r = 0.27$) were not statistically significant but suggestive. A larger sample size is needed.

Correlations between staff-reported student engagement on the STEM Activity logbooks were also suggestive: The observers' ratings of Relationships and Reflection were correlated with student engagement, .31 and .23, respectively. These correlations were not statistically significant, but are still suggestive. Again, a larger sample is needed.

D. ASSOCIATIONS BETWEEN DIMENSION OF SUCCESS RATINGS AND STUDENT OUTCOMES

Additional analyses were conducted to examine relations between the observational data of the quality of the STEM activities and student outcomes. We focused on four observed dimensions: Activities, Relationships, Youth Voice, and Reflection dimensions. These domains were selected because of the suggestive correlations found between staff reports of the quality of program activities (overall activity quality and student engagement), staff beliefs about STEM, and these observed dimensions. The logic model presented in Figure 1 posits that both staff beliefs and program activities are associated with student outcomes. Since the observation data revealed that these four dimensions were more closely related to staff beliefs and program activities, these dimensions were analyzed in relation to student outcomes.

Regression analyses were conducted to examine each of the selected dimensions (Purposeful Activities, Relationships, Youth Voice, and Reflection) in relation to students' post-participation outcome scores. Each of the dimension scores in these regressions were continuous ranging from 1.00 to 4.00, which corresponded to the four-point scale on which each dimension was rated. The dimension variables were used as a site-level means because only site-level identifiers were used

to match students' observation data at their sites. At the 52 sites in which observations were conducted, student surveys were matched for 1,949 students. Two control variables were also used in the regression model: student gender and students' pre-participation student outcome scores.

Results for the regression analyses are summarized in Table 11 below. Controlling for gender and pre-participation scores, a higher rated Reflection dimension was significantly related to higher post-participation outcome scores in science efficacy. Specifically, a one standard deviation increase in observed Reflection ratings was associated with a 0.07 standard deviation increase in students' science efficacy. No other significant relations were detected. Given the large number of analyses this relation should be interpreted with caution. At the same time, the fact that science activities were the predominant STEM activity in the programs, the relative increase in science efficacy is a promising area for further research.

Table 11

Associations Between Selected Dimensions and Student Post-Participation Outcome Scores

	<u>Student Outcome</u>	<u>Beta</u>
Purposeful Activities	Work Habits	-0.01
	Reading Efficacy	0.00
	Math Efficacy	0.00
	Science Efficacy	0.02
	Misconduct	-0.01
	Science Interest	-0.01
	Science Career	-0.04
	Likelihood of Future Success	0.00
Relationships	Work Habits	-0.04
	Reading Efficacy	0.00
	Math Efficacy	0.00
	Science Efficacy	-0.04
	Misconduct	-0.01
	Science Interest	0.00
	Science Career	-0.01
	Likelihood of Future Success	0.04
Youth Voice	Work Habits	-0.01
	Reading Efficacy	-0.03
	Math Efficacy	-0.02
	Science Efficacy	0.00
	Misconduct	0.03
	Science Interest	-0.01
	Science Career	-0.04
	Likelihood of Future Success	-0.03
Reflection	Work Habits	0.01
	Reading Efficacy	0.01
	Math Efficacy	0.03
	Science Efficacy	0.07**
	Misconduct	-0.02
	Science Interest	0.04
	Science Career	-0.01
	Likelihood of Future Success	0.00

$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Section IV. Conclusions and Recommendations

The purpose of this study was to document professional development, staff beliefs, program activities, and student outcomes during the first full year (2013-14) of the implementation of the *Power of Discovery: STEM²* Initiative to determine if the Initiative was on track to achieve its objective of improving STEM teaching and learning in California afterschool programs.

Our analyses revealed substantial needs for STEM professional development. The majority of the line staff in the participating programs had “some college”, but did not have either an AA or BA degree. The majority of the staff were young adults, between 18 and 25 years of age. The sites experienced significant turnover, with most of the staff having worked at their respective sites for two years or less. Many had worked at the site for six months or less.

During the 2013-14 initiative implementation, several notable changes in program offerings occurred. The line staff reported attending more trainings in the STEM area and having more frequent discussions with classroom teachers about STEM concepts being taught in school. In addition, staff reported an increase in the numbers of meetings with parents to discuss STEM programming and in numbers of STEM-related events for parents such as science fairs and family math nights.

These types of experiences were found to associate with desirable outcomes in terms of cultivating staff beliefs about STEM. For example, staff meetings amongst themselves to discuss STEM programming was related to stronger staff beliefs about the value of STEM learning and efficacy for implementing STEM activities. Further, staff meeting with teachers to discuss STEM topics being taught in school was related to an increase in staff efficacy for implementing STEM activities.

Cultivating staff beliefs proved to be worthwhile in terms of findings relating staff beliefs to program activities. Program activities, as measured by the STEM activity documentation forms, included measures of the overall activity quality, level of perceived student engagement, and level of activity challenge experienced by students. Staff beliefs about STEM and efficacy for implementing STEM activities were positively associated with various aspects of program activities. Specifically, stronger staff beliefs about the value of STEM learning were related to higher levels of activity challenge and student engagement as reported on the activity logs. Further, greater perceived efficacy for implementing STEM activities was found to predict greater student engagement in STEM activities.

Staff beliefs were also linked with gains in student outcomes. Stronger staff beliefs about the importance of STEM learning and perceived efficacy in the STEM area were linked to student reports of higher math efficacy. This finding suggests that staff beliefs may provide a strategy for improving student performance given math’s place as a foundational key to accessing and succeeding in STEM content. Aspects of program activities were also found to relate to gains in student outcomes. Staff-reported activity challenge predicted gains in student reports of work habits, math efficacy, reading efficacy, science interest, science-related career aspirations, and lower levels of misconduct. These findings suggest that activities be planned in a careful manner in an effort to appropriately challenge each student. Differentiated instruction, scaffolding, and

operating within students' zone of proximal development can help facilitate progress towards this goal.

In terms of professional development changes that occurred during the PoD initiative, an increase in time spent per week implementing STEM activities resulted in students reporting a stronger sense of math efficacy. Staff discussions with classroom teachers about STEM topics being taught in school were associated with an increase in students' efficacy for learning science and likelihood for a successful future. Lastly, staff meeting with parents to discuss STEM programming and holding events for parents was associated with increases in students' efficacy for learning math and science. These findings suggest that helping staff build bridges of communication amongst themselves as well as with teachers and parents can foster adaptive gains in student outcomes directly.

Observation data indicated that the programs participating in the Initiative were strong in Space Utilization and Materials, which amounts to observers reporting consistent and meaningful evidence that the space is utilized in a manner that is conducive to out-of-school time STEM learning and that the materials selected or developed by staff are appropriate and appealing to students. Correlational analyses suggested that staff beliefs about the importance of STEM learning was positively related with observed Purposeful Activities (the activity is purposeful and opportunities are capitalized to guide students towards STEM learning goals), Youth Voice (activities observed encouraged student opinion), and Relationships (relationships among students and between students and staff are positive). Staff reports of overall activity quality and student engagement in the activities suggested a positive relationship with observed Relationships and Reflection (students have multiple opportunities for meaningful reflection and for making connections between their experiences and the STEM content they are learning). Staff reports of activity challenge suggested a positive relationship with observed Participation and Materials. Because the observation study was conducted at only a sub-sample of sites and only some of the observation sites provided survey data, this portion of the 2013-14 study is under-powered to detect statistically significant relationships. The results suggest the value of additional work in this area.

The most significant limitation of the current study is that its design did not include a control or comparison group. Future research should collect surveys and observations of a broader range of programs, including programs that are not participants in the Power of Discovery Initiative. Including these non-participant sites will provide a more rigorous test of the *Power of Discovery: STEM²* Initiative.

References

- Noam, G. and Deborah L. Vandell (PIs), (2014). *Internal and External Observer Use of the Dimensions of Success (DoS) Observation Tool: A Collaborative Study in Northern and Southern California*. Conducted by PEAR at the Harvard University and the School of Education at University of California, Irvine. Report to Noyce Foundation and Bechtel Foundation.
- Noam, G., Larson, J., Dahlmer, C., (2008). *Dimensions of Success Observation Tool*. Program in Education, Afterschool and Resilience (PEAR). Harvard University.
- Noam, G., Sneider, C. (et. al.), (2010). Common Goals, Common Assessments: Evaluation Guidelines for Youth Programs. Unpublished manuscript, Program in Education, Afterschool and Resilience (PEAR). Harvard University.
- Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education*, 18(2), 341-363.
- Vandell, D. L., Warschauer, M., O'Cadiz, P., & Hall, V. (2008). *Two year evaluation study of the Tiger Woods Learning Center*. Report to the Tiger Woods Foundation.