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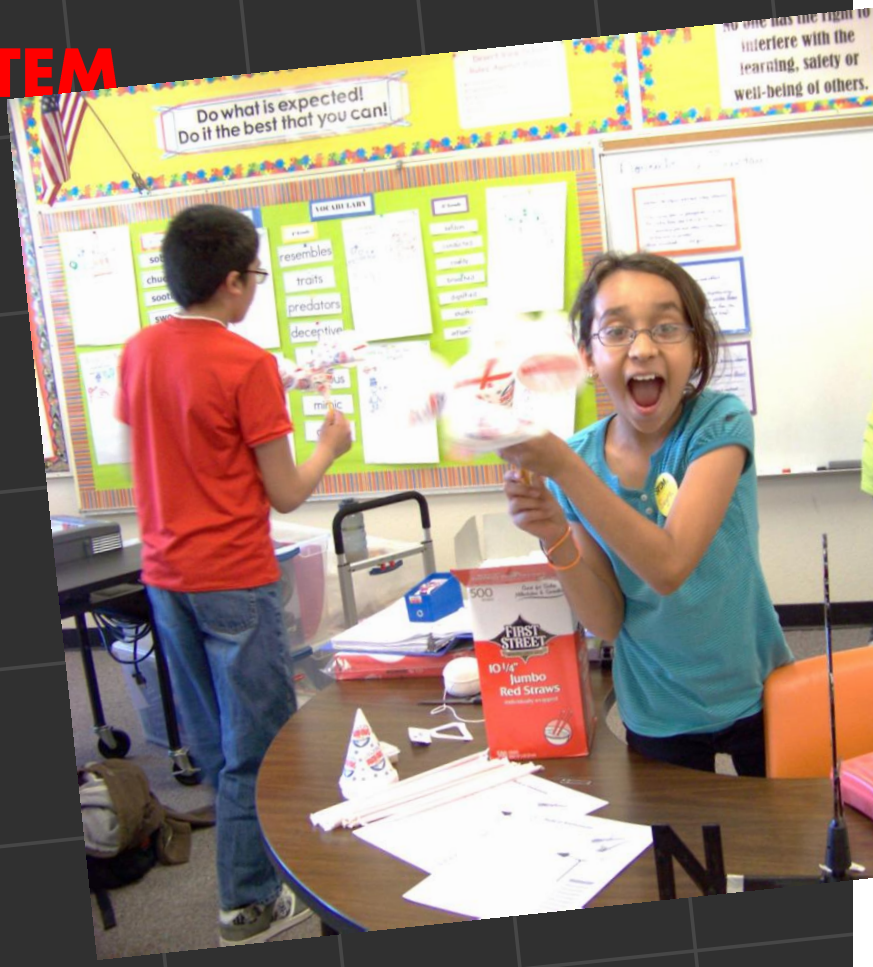
A 21ST CENTURY COMMUNITY LEARNING CENTER/MUSEUM PARTNERSHIP FOR AFTER SCHOOL STEM

JUNE 2013



STEM club
Science Technology Engineering Math

Arizona Science Center. (2013). *21st CCLC STEM Project Final Report*. Phoenix: ASC.

For the Partnership

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An instructor's blog:

"...The greatest revelation came this last Tuesday. In it was the quintessential moment in which *progress* and *perception* joined together to create the uncommon feeling of 'realization.' To be more specific, a little girl with a rambunctious attitude and free handed goals to be a pizza girl explained her reasonings why she was going to work at Papa John's, '...because my mom, sister and other sister all work at a pizza place, so I am going to also.' I was unsure how to approach this. I left for the week thinking of how many children are unaware of the potential they hold. With closed eyes dreams and one lunged breathing this little girl may very well never swing from the trees of achievement or inhale the sweet fragrance of contributing to society. Nevertheless, this last Tuesday while coming to the end of the class, the little blonde girl looked up from her seat and with a smile wider than mine said in a calm voice, 'I want to be a Chemist.' Pausing, unsure and unable to judge the sincerity of this statement, I asked what happen to the pizza undertaking? 'I don't want to be that anymore; I want to be a chemist.' I don't think that I will ever get used to that..."

A 21ST CENTURY COMMUNITY LEARNING CENTER/MUSEUM PARTNERSHIP FOR AFTER SCHOOL STEM

EXECUTIVE SUMMARY

For the past five years, the Arizona Department of Education (ADE) and the Arizona Science Center conducted a partnership to provide STEM camp and after school club experiences to children as part of the state's 21st Century Community Learning Centers (21stCLCC) program. The program has served over 3500 children in 85 programs at more than 40 schools. The program, which provided the instructors and the materials, offered a variety of STEM activities, take-home materials, family nights, and field trips to the Science Center. The program also trained pilot teachers from participating sites to conduct Clubs and Camps themselves, as assistants to the instructors or on their own. Six STEM evening events for educational and business leaders were held at the Science Center to inform the community stakeholders about the project activities and the importance of informal STEM programs.

Goals of the ADE for the program were as follows:

- Motivate students in grades 4-6 to STEM careers so that they choose to accomplish math competency prior to 8th grade
- Inspire students who might not otherwise follow a math or science path, including females, minorities, students with disabilities, etc. so they might realize their potential
- Relate programs to local and cultural variations, particularly for Native American sites
- Provide students and their families with STEM-related motivation and experiences to stimulate lifelong interest
- Employ 21st CCLC instructors and teachers who are trained by qualified staff developers in inquiry-based learning
- Impact the regular day school's ability to implement STEM
- Provide experiences for business/industry, community organizations, educators, students and parents related to STEM and motivate them to expand STEM in their various spheres of influence

Research showed that children participating in the program gained significantly in positive attitude to STEM, in considering careers in STEM fields, and in how they viewed themselves as STEM learners. Parents were universally pleased with the program and with their children's reactions to participating. Pilot teachers reported benefiting from the training and bringing some of the activities into their regular day classes during the semester following the Club/Camp experience. The goals of the ADE were achieved and findings suggest that the program would be important to sustain for long term impact.

A 21ST CENTURY COMMUNITY LEARNING CENTER/MUSEUM PARTNERSHIP FOR AFTER SCHOOL STEM

PROGRAM OVERVIEW

In June of 2009, the Arizona Department of Education (ADE) and the Arizona Science Center began a partnership to provide STEM experiences to children as part of the state's 21st Century Community Learning Centers (21stCLCC) program. The 21st CCLCs provide funding for after school programs that serve approximately 200 schools across the state in low-income and minority communities. In addition to enrichment programs in arts, sports, youth development, and a variety of other subjects, the ADE thought it might introduce resources for science, math, technology, and engineering as an option to schools, something they hadn't done before.

Goals of the Arizona Department of Education

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- Relate programs to local and cultural variations, particularly for Native American sites
- Provide students and their families with STEM-related motivation and experiences to stimulate lifelong interest
- Employ 21st CCLC instructors and teachers who are trained by qualified staff developers in inquiry-based learning
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The Science Center, which conducts outreach programs to around 15,000 student annually plus runs its own summer camps, library programs, and workshops, was a natural partner for preparing instructors in informal STEM programming, assembling engaging, hands-on materials, and offering a parent evening and a field trip as part of a camp program.

A Brief History of the Partnership

In 2009 the Arizona Department of Education staff invited ASC to join in a STEM partnership, primarily because ASC already provided some STEM curriculum and camps and there was easy access to year-round hands-on science facilities. Before proceeding, the ADE required that the partnership identify meaningful family engagement that would promote STEM interests at home. Other features that were essential were built into the contract scope of work and became part of the partnership objectives. ADE managed the competitive STEM grant process, issued and monitored the five-year partnership contract, meet monthly for contract oversight and participated in co-designed public meetings related to STEM.

Our partnership began as a three week-long summer camp program for each of five schools in three cities in the state, Flagstaff, Phoenix, and Tucson. The programs were considered to be "pilots" for possible expansion or continuation in future.

Camps ran between 3 and 4 days a week, between 3 and 5 hours per day, depending on the site. Flagstaff and Tucson hosted one camp group during each of three weeks, led by the same instructor. In Flagstaff, a differently themed camp program was offered each of three weeks (Engineering, Physics, and Earth and Environmental Science); in Tucson, the camp activities were repeated each week and included one day of Physics, one day of Engineering, and one day of Biochemistry. In the Phoenix Metropolitan area (Tolleson), three camp programs ran simultaneously for three weeks, led by three instructors. There, each child rotated between the three themed programs (Engineering, Physics, and Biochemistry) over three weeks and therefore had a longer exposure to science camp activities.

The program consisted of themed hands-on science and engineering activities. Some weeks, guest presenters—scientists or engineers—gave brief career talks to the groups. Instructors were given a plan and materials for a sequence of activities but they were encouraged to add to the plans, for instance, developing math and writing aspects, and to follow the interests of the children. Therefore, the sessions varied by instructor, group, and week and cannot be compared directly. Tucson and Tolleson kept the ages of the campers homogeneous; in Flagstaff, campers were mixed in ages. Children all experienced a field trip to the Science Center as part of their program and two sites (Flagstaff and Tolleson) elected to hold a Family Science Night where the Science Center's Outreach Specialist visited and offered hands-on activities to the campers and their families.

In the fall and spring following the pilot summer program, a total of 16 sites were offered a 10-week after

school Club sequence which also included a 4-day summer camp for each site. Each program had weekly take home materials for families (To Go bags), a field trip to the Science Center, and a Family Night. Instructors were trained and deployed by the Science Center. The curriculum this time took children through components of a project that culminated in their designing and building a mechanical toy, so the sessions were on things like design, gears, electricity, robotics, animal models, and so on.

The third year, the ADE wanted to pilot a program where teachers from the school sites trained along with the Science Center instructors and were given materials for Club workshops they could conduct on their own two days per week after the Center-led session. The curriculum was divided into five 2-week units (6 sessions in all) on a number of different science or engineering topics. We worked with 10 sites each semester that year and had 10 teachers in the spring semester participate in the pilot.

During the fourth year of the partnership, we again worked with 20 sites, training teachers as well as instructors, but offering two Club sessions each week instead of three which seemed to be more feasible. In honor of the State of Arizona's centennial, the curriculum was a desert science program. During year five, the program was carried out in 20 sites as well, focusing on the Desert in the fall and Sustainability and Biomedicine in the Spring. In that semester, two different Club curricula were produced so that children experienced two different content themes over the 10 weeks of Club time.

Components of the Partnership

The Scope of the Partnership Work

The initial agreement between the two agencies meant that the Science Center received a contract that supported startup and development costs. The contractual piece of the relationship has continued because each year, we have piloted a new and increasingly deep set of questions about involving teaching staff in training and delivery of after school STEM activities.

In addition, districts that had funds allocated for 21st CCLC programs issued purchase orders to the Science Center for the after school services themselves. Those services ultimately included: a trained instructor employed by the Science Center to deliver all programs; all materials and take-home materials; a full-day field trip to the Center that included a movie or planetarium show; in some cases an overnight at the Center; and, a Family Science evening event.

Thus, in the fall and spring of 2009-2010, following an experimental summer camp with Family Science Night and field trip in 2009, we expanded the program to a 10-week after school club at 8 sites each semester. The next academic year (2010-11), we developed two additional sets of

activities that expanded the instructor-led Club session and trained the school's teachers to conduct two extra Club sessions per week over 10 weeks. We also added take home activity materials each week as well as the week long summer program and second field trip.

For nearly five years a Program Specialist from the Arizona Department of Education's 21st Century Community Learning Centers unit worked closely with the Science Center STEM Community Outreach staff, working out contracts, making sure we had the target elements in place and were on budget, and doing presentations for the instructors and the guests at our bi-annual STEM Fest. The ADE and ASC met monthly and sometimes more often.

Site Selection

The Arizona Department of Education created an on-line application process for those sites who wanted to participate in STEM After School Clubs and Camps. A committee of ADE staff reviewed school applications and scored them according to a rubric they developed. The panel looked for: sites that were not in their first year of programming, in order to make sure the sites were running well; that there was a commitment from administration for STEM exposure; and procedures in place for recruitment of underserved children.

Inquiry-Based and Other Activities

As much as possible, ASC wanted to introduce activities that were inquiry-based and that touched on topics and materials of high interest to students. Designed by curriculum consultants and science staff developers and borrowing from a number of sources (such as EDC's Design It! materials) including our own camp programs, the programs were experiments in sequences and topics. The program mixed step-by-step activities and challenges with true inquiry activities.

During our first, pilot summer camp we offered sites a "picnic basket" of activity themes they could choose from. They could have each day of the program cover a different STEM area (biology, physics, environmental, engineering) or have the whole week focus on one topic. During the first 10-week Club program we offered a series of component STEM workshops that culminated with the children designing their own mechanical toy. Some of those sessions covered design, gears, levers, batteries and bulbs, robots, and biomechanics.

The next year, we offered five 2-week units on a variety of STEM topics: Making the Band, Lemonade Stand and Chemysteries, Farming to Fuel, and Where the Wind Blows and the Sun Shines. This year, in honor of Arizona's Centennial celebration, we designed a curriculum of inquiry around the desert environment, including explorations of soil and rocks, heat and sun, and

water and life forms. With limited resources at the sites and a limited budget, these were not high tech experiences, however, this past year we were able to purchase handheld tablets and iPad2s and introduce links to desert videos and images (say, of dust storms) as well as use them for GPS-linked activities. During the 2012-2013 school year we offered the desert science curriculum and two new curricula in the spring: sustainability and biomedical science.

Children responded well to different types of curriculum approaches). The staff is considering which type worked best for our educational goals and how to now re-cycle or use prepackaged materials (such as the forthcoming Maker Faire kits from the Exploratorium) to reduce development costs.

A complete listing of the curriculum topics for each year is included in Appendix A.

Underrepresented populations

Children participating in the camps range from rising 5th graders to rising 8th graders, mostly in homogeneous groupings by age. Each site is a Title I school so the children are primarily low income and minority. We have worked with schools with predominantly Latino children and on two Indian reservations. Schools have had a good distribution of girls and boys but fewer special needs students.

Children are recruited to participate through different means, usually teacher nomination or being invited to attend by the school. One site asked students to write an essay on why they should attend a science camp.

Cultural Sensitivity

During instructor and teacher training, we review issues related to different cultural groups and how the children and their parents might respond to the projects and the format of a Club. The take-home materials and parent surveys are bi-lingual (Spanish and English). The main issue we have encountered because of cultural differences relates to southwest Native American tribe taboos on dissection (e.g., owl pellets). When children from Native American reservations came to the Center for an overnight camp-in, we covered up exhibits with human tissue specimens and had them sleep in different areas.

An additional issue among all minority groups, is the lack of role models in their lives who are engaged in technical professions. All of the families have members with technical expertise of various kinds but they may not have degrees or jobs in engineering, medicine, industry, and such.

Otherwise, the teamwork afforded by informal setting works very well for all the children, who uniformly, across communities, rate the Club/Camp experiences very favorably.

Funding for Pilot Activities

Pilot funding supported curriculum development; teacher training; logistics of assuring that all regions of the state are served including Indian reservations; monitoring for continued compliance to the pilot design; and, evaluation.

Supplies

One of the most helpful aspects of the project was having the budget to buy and organize materials for each site and to have a staff member in charge of ordering and organizing. The Science Center has a volunteer crew as well, who were vital to sorting, counting, and packing up the myriad supplies we provided to each site, a total of 10 large tubs-worth per semester and 5 tubs for camps. We were also fortunate to have access to enough space, temporarily, to lay out the materials and store them.

Non-consumable materials were loaned to the sites. Instructors and teachers brought them out at the time of their training and returned them at the end of the Club or Camp period. If the instructor couldn't manage an ASC staff member delivered the tubs and picked them up.

Our budget for materials is large but we have learned where to shop and how to recycle. Club plus camp materials average $77 per child, with the take-home To Go bags adding $7 to the cost of materials. On average, about 60% of supplies are non-consumable and were returned to the Center for future use.

Family and Community

In order to inspire and motivate students, there is a need to involve parents in the excitement created among children by the program. We addressed this in several ways. First, we provided weekly take-home ("To Go") bags with simple materials that allow children to do an activity at home that connects with what they did that week in Club. For example, when they participated in the Design and Build It session, they received a bag with an activity called "Tough Triangles" that challenges participants to make a three-dimensional structure based on triangles that is capable of holding an object. With Campfire Science they received an Inclinometer – an instrument for measuring angles of slope (or tilt), elevation or depression of an object, to collect and analyze data from their own backyards.

In the past year, a Career Highlight section was added to the "To Go" bag featuring a description of technical careers related to the activity.

Secondly, the Science Center's outreach staff came each semester to the Club's site and held a Family Science Night. This is a 2-hour festival with activity stations that accommodates up to 300 people. Whole families can participate; sites sometimes have children show off their projects as well or combine the evening with activities related to other 21st CCLC clubs they may be offering.

Field Trips

Each Club group participates in two field trips to the Science Center: one during the Club session and one during the summer Camp time. Groups that were coming from more than a 3-hour drive away got to spend the night at the museum on their field trips. On all field trips, the children experienced the 300+ hands-on exhibits at the Center and saw a planetarium show or movie. Transportation was supported by the project budget, and arranged by the Science Center.

EVALUATION

From the beginning, we designed evaluation instruments that would give the Department of Education and the Science Center feedback about the strength of the program for achieving its goals. It also gave us feedback about how we could improve the program. Because of limited resources, we couldn't directly address all the goals of the program but we were able to collect data about some key issues. We also collected indirect evidence of success through anecdotes, as when several districts decided to expand their daytime STEM programming because of the Club experience.

The evaluations were designed and reported by the Director of Science Interpretation at the Arizona Science Center. Funding for a research assistant was budgeted. Instruments included: activity observation forms; children's pre- and post-program survey; children's post-program written commentary form; and, parent evaluations.

The first two years, we collected data as follows:

Evaluation Schedule	Measure
First Day	a. 1/2 hour observation b. Children's Pre Survey
Last Day	a. 1/2 hour observation b. Children's Post Survey c. Post Questionnaire d. Parent Survey

During the next two years, we kept the Children's pre- and post-program survey and one round of parent surveys. During this time, however, the teacher pilot piece was introduced, in which classroom teachers were trained to conduct after school sessions, so we tracked the impact of that.

Children's Responses

Pre-Post Surveys

During the summer of 2009, the fall of 2010 and the fall of 2011, children participating in the programs were given a 5-question smiley face survey on the first day of the program and on the last day.

The questions asked them the degree to which they agreed (on a 5-point scale) with the following statements:

I think science is interesting
I enjoy building things
I like to figure things out
I think about becoming a scientist or engineer
I look forward to taking science and math next year in school

The results were analyzed overall, by sex, by grade, and by school. A total of 526 children completed both the pre- and post-surveys. Significant overall results are shown below, with exceptions noted. In some cases where there was no change, we saw a possible ceiling effect; that is, the children started out with high ratings. Overall, the programs showed a positive impact on children's attitudes.

Significant Pre- to Post-Program Changes in Ratings

Survey Question	2009	2010-11	2011-12	2012-13
I think science is interesting	↑*Overall ↑Girls ↑3-wk Campers	↑Overall	No change (positive trend)	No change (possible ceiling effect)
I enjoy building things	↑Overall ↑Girls ↑3-wk Campers ↑6th Graders	↑Overall	No change (positive trend)	No change (possible ceiling effect)
I like to figure things out	↑ Flagstaff ↑4th Graders	↑Overall	No change (positive trend)	No change (possible ceiling effect)
I think about becoming a scientist or engineer	↑Overall	↑Overall	↓Decrease Girls ↓Decrease 5th Graders	No change (possible ceiling effect)
I look forward to taking science and math next year in school	No change	↑Overall	No change (positive trend)	No change (possible ceiling effect)

* arrows indicate significant differences, positive and negative

Post Questionnaires

In addition to the Pre- and Post-Surveys, children participating in the programs were asked seven open-ended questions about their experience. Some groups did not complete the written evaluation because the instructors forgot to distribute forms.

What they liked

Overall, the children thought the programs were great. When asked what they particularly enjoyed, many children mentioned specific experiments. building things "everything," making things, experiments in general, having fun, working in teams, the field trip to ASC., and learning things.

Many children who participated in the camp also mentioned that they enjoyed the IMAX movie they saw on their visit to the Center.

Most interesting activities

The children were asked what activities or topics of the program were particularly interesting to them. Each group experienced different sets of activities and so the answers varied but everyone had favorites.

"The topic I like was making sound and making the solar cooker."
"When we made ear drums and learned about them."
"When we get to take notes on different subjects."
"Making the toys and inventing a different shaped kite."

Many camp participants mentioned that exploring the Science Center was particularly interesting to them.

"I learned I really like science."

"I learned that I'm good at science."

"I learned that I am smart and that I know things."

"I can do anything if I put my mind to it."

"I learned that science is fun when you get really into it."

"I learned that I am very creative and smart."

"I have learned that I am smarter when it comes to building stuff."

"I can make different things with many things."

Attitude to mathematical activities

We asked children how they felt about the measuring, planning and designing they were asked to do and whether they found it hard or easy. Most of the children enjoyed it, a few didn't, and some didn't address whether they enjoyed it. Of those who enjoyed it, many found it easy, some found it hard, and a few both easy and hard. Those who didn't enjoy it because of the difficulty level were split between finding it too hard and too easy.

What they felt they learned

When asked to name something new they learned about science or engineering, many children mentioned learning how to make or build things such as the solar cooker or bug spray. Other common responses included learning something about science and engineering, camping and survival, new ways of seeing the world, what it takes to be a scientist or architect, and "everything."

"I felt smart and I did enjoy it and it was easy and hard."

"It felt great to design, plan, and measure. I enjoyed it all because it was easy."

"I enjoyed it and it was hard."

"I did enjoy the measuring, planning, and designing."

"I learned there are many steps to planning and designing."
"Science is everything."

What they learned about themselves

When asked what they learned about themselves throughout the program, the children mentioned learning that they like

science, that they are good at something, that they are smart or capable, and that they want to be an architect or scientist.

Only a few children didn't think they learned anything about themselves.

Opinions about the instructors

The children mentioned a variety of positive qualities to describe their instructors, including nice, awesome, fun, cool, a good leader/teacher, smart, good/great, helpful, teaches interesting things, and the best.

> "I like him, he is very nice & explains topics & the directions of a project."
> "She was very nice and good about telling us what to do. She is also a good helper."
> "She is nice, helpful, and awesome."

Suggestions for improving the program

When asked if they would change anything about the program, most echoed the sentiment, "I wouldn't change anything because it was all fun." Some suggested changes to the activities such as offering the program to more kids, building or making more things, spending more time outside, more field trips, more science, and wanting to be in the program more often or again.

Many also would have liked the program to run longer. A few camp participants suggested changes to the sleeping arrangements on the overnight visits to the Center (later bedtime, more comfortable sleeping areas).

"I think that we should let more people be in the program."

"I would change that the science club will never end."

Observations

Observations of children's engagement levels were conducted during the summer of 2009 and over the year in 2010. In both cases, the methods and results were similar.

Observations lasted a half hour, with ratings being made every five minutes for one minute. Observers estimated the level of participation of the majority of the children on a 4-point scale where:

1= not engaged: not engaged: inattentive or appearing uninterested;
2= minimally engaged: glancing at and viewing materials, but not exploring or discussing;
3= somewhat engaged: content but not enthused, doing the activity as a side act;
4= fully engaged: exploring, experimenting,interacting with each other and/or materials.

For the club activities, ratings ranged between 3.5 and 4 for the 2010 club at the beginning of the programs, and between 3.8 and 4 for the final observations. This suggests that across a variety of activities and consistently during the sessions, the majority of children were engaged and interacting with the content. Camp engagement was rated on a 3-point scale and those ratings ranged from 2.3-2.5 the first day of the program to an average of 2.8 at the end.

The written comments by the observers also showed that, in both sessions, the majority of the children were highly involved in the activities, exploring, experimenting, and interacting with each other and the materials throughout the entire program. Children were highly engaged from the start even though, in some cases, they didn't know each other and were meeting the instructor for the first time. Observers noted inattention by some children at certain transition times for example, while instructions were being delivered or when materials were distributed.

Responses from Parents

Ratings

We conducted research about what parents thought of their children's experience. Club instructors gave parents (or adults responsible for each child) stamped, addressed envelopes and a one-page evaluation (in English and Spanish) to return. Five questions provided a rating scale and five open-ended questions allowed parents to write comments. A total of 169 responses were collected over three seasons.

The questions asked them the degree to which they agreed (on a 5-point scale) with the following statements:

My child enjoyed the club.
At home, my child talked about what they did.
I felt the program was a good experience for my child.
I would like to send my child to a program like this again.
I would be interested in learning about an after school program like this.

Ratings were overwhelmingly high for each question although not all parents reported that children talked about what they did once they got home. Results from the first session were:

Numbers of Parent Responses to Each Question

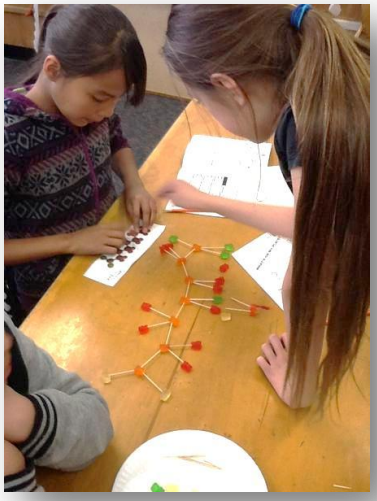
N=74 [15 in Spanish]	A LOT	SOMEWHAT	NOT AT ALL
My child enjoyed the week of summer science camp	73	1	0
at home my child talked about what they did	63	11	0
I felt the program was a good experience for my child	72	2	0
I would like to send my child to a program like this again	73	1	0
I would be interested in learning about an after school program like this	64	9	1

Open-ended questions

Open-ended questions showed that every parent responding would have liked their children to continue participating in such a program.

Parents reported that their children particularly seemed to like the hands-on activities. Popular activities reported were: squid dissection, Jitter Bots, and bottle rockets.

The only negative reactions noted by parents among their children were their reactions to the food served and to the requirement to wear uniforms. One parent reported her child was "squimish" about dissecting squid.



Parents were asked if they noticed anything about their children as a result of the camp experience. Three themes emerged: that their children discovered a new interest in science; that the children wanted to talk about or try the experiments at home; and, that their children learned they were capable of doing science.

Asked what they particularly liked about the program for their child, the dominant theme among responses was that parents were happy to see their child so enthusiastic, motivated, and learning new things. They also cited that the camp gave them peace of mind and was free.

Most also agreed that their child "has a lot more questions about science and a bigger interest in it." They also cited that the camp gave them peace of mind and was free.

Every parent responding would like their children to continue participating in such a program.

Evaluation of the Club experience by pilot teachers

Training

To evaluate the pilot teacher training during the fall of 2011, we had teachers keep logs of activities each week; we conducted interviews with the teachers; and the project had teachers communicating with a mentor through blogs, which we analyzed. We also conducted phone interviews with teachers during the semester following their training and after school work, to see if any of the practices transferred to their regular classroom routines.

Teachers who participated in STEM Club training in the spring of 2011 filled out evaluation forms at the conclusion of the three-day training session.

When asked how much they felt they learned on a scale of 1-6 about STEM content, Hands-on Activities, and Informal Instructional Techniques, most reported that they learned a lot.

NUMBERS OF TEACHERS RATING EXTENT OF LEARNING FROM TRAINING

Rating	1 (not at all)	2	3	4	5	6 (a lot)
STEM CONTENT	0	0	0	1	2	8
HANDS ON ACTIVITIES	0	1	0	1	1	8
INFORMAL INSTRUCTIONAL TECHNIQUES	0	1	0	1	1	8

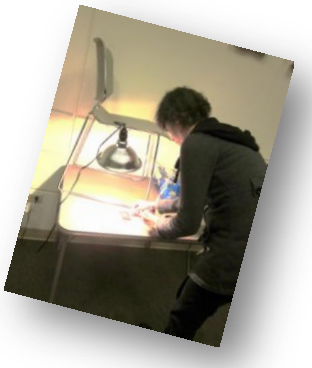
Teachers generally felt the techniques would be useful, that they gained motivation, and that the workshop met or exceeded their expectations.

TEACHER RATINGS OF TRAINING

	NOT MUCH	SOME	A LOT	A GREAT DEAL
Did you learn techniques that will be useful to you?	0	2	2	7
How motivated do you feel to do these activities?	0	2	1	8

	MISSED	NEARLY MET	MET	EXCEEDED
To what extent did the workshop meet your expectations?	0	2	2	7

Teachers were asked for suggestions for improving the training workshop. A few less experienced teachers would have liked to have more background science presented, general orientation to the materials, and different pacing. While there were a few suggestions for improvements, many teachers reported on what they found valuable as well.



Teachers' Observations of the Six Strands of Informal Science Learning

Teachers' weekly comments about the activities showed evidence of all the hallmarks of informal science learning, as outlined by the recent report from the National Research Council (2009).

Motivation and Interest

"When one student asked what we were going to do in STEM club, Regina responded that we were going to have '2 hours of

awesomeness.' I also had Jennifer tell me how she teaches everything she learned that week to her cousins that come over on the weekend. Sometimes they do "STEM-to-go" [take home kits provided each week] together."

"The anemometers were a big hit. they took longer to assemble than planned and were rushed with the 'making wind work' some groups finished others did not but took the materials home to finish."

"Everyone wanted to volunteer during the refractometer activity. They took notes, cleaned pipettes, disposed of trash and prepared the liquids. "

Understanding and Content Knowledge

"'We keep having to move the solar car to make it work.' The students moved from an area with mixed sun and shade to a sunny spot to race their cars."

"One boy created an 'instrument' from a shoe box which had tuners that resembled tuning keys on a guitar. His explanation: 'When I turn this stick on the end of the box, it tightens the fishing line and makes one sound. When I loosen it with the other stick, it makes another sound.'"

Scientific Reasoning

"Kids were very intent on getting that pH number just right. They were very good about not just dumping in sugar (although they wanted to)."

"We turned the Wind Can Do Work activity (started the previous week) into a competition to help motivate. The kids got really excited about adding paperclips. The weather vane activity takes this group a little longer to get the concept and create their own ideas. Some were very successful. Laminated sheet helped."

Reflecting on Science

"We were doing the surveys today and it was fun to hear the kids reminiscing over the past clubs and trying to remember the most activities."

"When creating the 'best lemonade,' one boy said that he was too impatient. They had already gotten a pH of 4 - to match their favorite brand, but he had impulsively added more citric acid without thinking about what would happen next."

Engaging in Scientific Practice

"It was wonderful to see the children retest and recreate their anemometers. We also took them outside to test - they loved that."

"Lots of good experimentation from this group. One girl explained while we were testing the bee hummers that by shortening the string it made a sound different from when the string was long."

Science Identity Building

"Michael was wondering aloud about talking to or asking a scientist about something, then promptly exclaimed, 'Wait a minute, I am a scientist!'"

"Loved the lab coats, goggles and gloves. Were eager to help in any possible way. Very disappointed they couldn't bring anything home including the 'chemistry in a bag.'"

Running the Clubs

The classroom teachers participating in the pilot project were asked to keep logs of activities each week; we also conducted interviews with the teachers; and the project had teachers communicating with a mentor through blogs, which we analyzed.

What pilot teachers learned

The questionnaires completed before and after training showed that teachers participating in the pilot program were, for the most part, enthusiastic and skilled in science instruction at the outset. They were expecting to gain professional skills and understanding by participating in the project and felt they did that. Teachers felt they learned a lot from the training program and were appreciative of the new activities and of the materials they received.

What they did

Analysis of weekly electronic surveys, written surveys, and debriefing discussions during and after the Club sessions showed that all pilot program teachers were able to carry out the STEM Club extension sessions and to adapt activities and timetables to suit their respective sites. Teachers who

were well-informed by their districts about the time commitment needed for the program before they signed up were able to carry out the sessions during the school semester; two teachers had to run the Clubs during the summer break because they did not have time otherwise. Sessions held during the school year all took place in out-of-school time. It is not clear yet whether pilot program teachers will use the ideas in their classrooms in the future.

What they used

Not every site used every module or met with the same frequency. The activities, however, were flexible enough to be adaptable to the needs of different sites, to changing situations, to different age groups, and participant backgrounds.

What support they needed

The support from ASC Instructors was welcome and varied. Most of the contact between teachers in the program and ASC Instructors consisted of weekly face-to-face meetings, during which a wide range of issues was covered, from practical concerns to pedagogical questions. Having all but a few perishable materials provided was a particular strength of the program in their view. Collaboration between the teacher and the ASC Instructor meant that logistics were handled locally and directly.

General themes

Comments from pilot program teachers showed evidence of all six indicators of science learning according to the 2009 National Research Council report: Motivation and Interest, Understanding and Content Knowledge; Scientific Reasoning; Reflecting on Science; Engaging in Scientific Practice; and, Science Identity Building.

In sum, the model had an immediate impact and resulted in teachers conducting STEM activities that children very much enjoyed and that engaged them in science-related learning during after school hours. Instructor support was important for supporting the teachers and for organizing practical issues associated with implementation. The modules and materials were adaptable and flexible so that they were usable for the range of sites and locations.

The semester following the Clubs

Ten teachers who participated in a pilot STEM training program and After School Club program during the spring of 2011 were interviewed by phone during the fall of 2011 to learn whether they incorporated any of the techniques and materials they had used into their regular school day classes during the new academic year. The majority of teachers reported noticing changes in their teaching as a result of the program. Seven of the ten teachers were using the activities they learned, which incorporate inquiry-based learning opportunities for students although fewer reported using the pedagogical techniques they learned. Half the teachers ran club programs on their own the next school year.

In comments regarding the Clubs themselves, teachers reported that the materials were very usable and complete; they found the support of the Science Center instructors to be a strength of the program; and they judged the Clubs to be successful. Recommendations to the program staff touched on: reaching more children, providing more planning time, simplifying implementation, and communicating with school administrators. Some felt that they needed more hands-on help to set up and run Clubs.

DISCUSSION

Since the inception of the ASC/ADE partnership for STEM After School in 21st CCLC sites, the field in general has advanced. For example, in the past two years, the U.S. Department of Education has invested in a program that brings a group of experts together to develop technical assistance tools for states that are implementing such programs. Both the ADE and ASC are represented on this Technical Working Group. The group is defining quality programs and identifying exemplary practices; developing a set of web-based tools to support program development for administrators and practitioners; and articulating what it means to offer experiences to underserved children that enlarge their horizons and motivate them to go on in STEM studies and careers. The Afterschool Alliance recently published the study Defining Youth Outcomes for STEM Learning in Afterschool, with support from the S.D. Bechtel, Jr. Foundation and the Noyce Foundation. The Coalition for Science After School, with over 5000 members, shares information and news about programs with sites across the country. The Girl Scouts has introduced a STEM objective for their programs and many other youth-serving agencies have adopted STEM objectives for their participants. The After School Corporation has posted its guidebook for leaders conducting science after school.

Notwithstanding the variety of programs and approaches that exists across the country, the field is becoming clearer about desirable outcomes and about understanding how to achieve them. This

project has contributed to the knowledge base by contributing data about the impact of our programs on children and because Arizona Science Center and the Arizona Department of Education are represented on the US DOE Technical Working Group. As the field moves ahead, we have the opportunity to learn from the national conversation and contribute to it.

Were the Objectives Met?

Motivate students in grades 4-6 to STEM careers so that they choose to accomplish math competency prior to 8th grade: with one year's exception, the program created interest among the participants in considering STEM careers. We did not look at course choices but did discover that children, overall, did look forward to studying math and science in the coming year.

Inspire students who might not otherwise follow a math or science path, including females, minorities, students with disabilities, etc. so they might realize their potential: with the one exception notes, all children in the program were inspired and seemed to view themselves as people capable of doing more.

Relate programs to local and cultural variations, particularly for Native American sites: cultural variations arose as part of the course of events. Instructors found ways to adapt the activities to their charges. Engagement levels were high in all sites, among all children.

Provide students and their families with STEM-related motivation and experiences to stimulate lifelong interest: while we cannot measure the impact of the experiences longitudinally, parents reported seeing their children in a new light and being happy to see the excitement for their children generated by the program.

Employ 21st CCLC instructors and teachers who are trained by qualified staff developers in inquiry-based learning: we did this through the pilot program. Teachers reported some transfer of activities and approaches to their regular classrooms.

Impact the regular day school's ability to implement STEM (see above): self-reports by teachers suggest that teachers realized the advantages of conducting exciting, hands-on explorations with students and tried to import them into their classroom routines.

Provide experiences for business/industry, community organizations,

educators, students and parents related to STEM and motivate them to expand STEM in their various spheres of influence: Six evening STEM Fests were held over the years, with community, education, and business leaders in attendance. Guest speakers presented inspirational information about the need for after school programs, fun activities were offered to the guests, and discussions were held about the importance of the 21st CCLC STEM after school experiences to the state of Arizona.

Follow Up with Sites

As we contacted sites who had participated in the STEM Club program, we learned about many outcomes that were unplanned but which were very interesting to learn about with respect to what a STEM after school program can lead to in a school or district.

The ADE contacted 43 programs to collect follow up, via an on-line survey, about their satisfaction with the program and how it affected the schools. Responses were provided by site administrators and in 18 cases by teachers who had been trained to run Clubs. Results showed that the great majority of sites felt Very Satisfied or Satisfied with the program, its value, and its impact on the school.

Responses on Follow Up Calls

Question	Very Satisfied	Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Dissatisfied	Very Dissatisfied
The ASC met the requirements of the STEM classes that I was anticipating	**27**	**13**	**1**	**1**	**0**	**0**
For the cost of the ASC program, received great value	**22**	**16**	**2**	**2**	**0**	**1**
The services from ASC were able to spark an interest in STEM impacting our school culture	**25**	**15**	**2**	**2**	**0**	**0**
The changes we've made to incorporate more STEM in our school for all students are noticeable.	**21**	**13**	**6**	**3**	**0**	**0**

Seventy-five percent of those interviewed would like the clubs and camps to continue. Over half the sites would like continued training by ASC for their after school and regular day school teachers. A little over 60% would like more family experiences and field trips to the Science Center.

In phone interviews 15 people, or 34%, reported that the participating teachers became excited about science and STEM such that it was integrated at the classroom level. Suggestions for improvement mentioned providing enough time for teachers to prepare and train; timing the training sessions earlier in the year; and, having the program for more than 10 sessions.

We heard many stories about how participation in STEM Clubs and Camps affected schools.

A few stories stand out:

- After a summer camp program, Phoenix Metropolitan area district decided to become a STEM district and hired a STEM Director and STEM Coordinator at each of their four schools to ramp up District curriculum.
- One teacher who was trained to lead a club, decided to continue her education in STEM; got a NASA grant for her school; went to NASA training; and is now a STEM teacher for the district. After her club experience another instructor decided to get a teaching degree and become a science teacher.
- A school on the Navajo reservation decided to continue the program at its own expense and sent the teacher for more training, purchasing activity kits for the following year.

IMPLICATIONS FOR THE FUTURE

STEM knowledge, according to Gerlach (2012) means many things to a variety of people. Teachers may focus on increasing student interest in STEM careers, while the employers may see it as having workers with the technological skills to solve problems in any field. Research, however, shows sustained pathway experiences–including perhaps after school experiences–empower students and "assume that it is never too late to participate or to return" (Lyon, Jafri, and St. Louis, 2012).

The after school STEM program field is still defining itself although what it means to learn science in informal environments is beginning to be recognized (NRC, 2009). The report, *Defining Youth Outcomes for STEM Learning in Afterschool* (Afterschool Alliance, 2013) also reports a difference

in perspective among experts and stakeholders on what the impact of after school STEM may be for student performance in school.

More and substantive research needs to be conducted on after school STEM programs (Afterschool Alliance, 2013). Out of School Time programs seem to increase low-income student interest in career paths but most seem to have only short term gains (Hynes, Greene and Constance 2012). According to Hynes (2012), "more research is necessary to help us understand which program models have the greatest effects, and on which youth." This work contributes information about short-term impacts related to children's interests, attitude, awareness, and potential to learn more.

Future Plans and Key Components to Maintain

The STEM partnership attained recognition following a federal grant monitoring visit from the U. S. Department of Education. As a result the ADE and ASC representatives, Dr. Mary Lou Naylor and Dr. Laura Martin became active members of the first U.S. Department, Presidents' STEM Initiative Technical Work Group. This association led to the opportunity to showcase our partnership and program at the 2012 U.S.D.O.E. 21st CCLC National Summer Institute (New Orleans). The ADE/ASC STEM team has also recently submitted a proposal the USDOE electronic showcase for 2013-2014.

For Arizona Science Center

As a result of the 21st CCLC STEM Club and Camp experience, Arizona Science Center gained significant expertise in running these informal programs. Thus, in addition to learning a lot about how children and schools responded to activities, ASC developed a repertory of programming components that we are now offering to other schools and community agencies serving children after school, on a fee basis. The Science Center plans to continue marketing those services and deepening the experience of what we offer. For example, in collaboration with the University of Arizona's College of Medicine, we are proposing to develop a two-year after school sequence on topics in biomedical discovery for middle school-age children, with funding from the National Institutes of Health. Our experience with the ADE program has fortified our case for Federal funding.

ASC staff, who designed the curriculum, trained instructors and worked with the sites to support implementation, identified a number of strengths of the project that would be important to continue in the future. These include:

- It is important to offer a menu of activities and topics for programs with lots of hands-on time and variety, targeting both girls and boys and different cultural communities.
- Activities, take home bags, field trips, and family nights are all valuable to continue.
- Homogeneous age groups are recommended.
- The program seems to be appealing and beneficial for children in all grades 4-8, particularly 6th.
- Boys and girls have different responses in some cases so that's another reason to pay attention to this dimension.

For the Arizona Department of Education

Dedicated funding from ADE for STEM pilot programs will end in June of 2013. However, the relationship has continued in joint meeting presentations in order to share the successful practices with STEM. All of the partnership objectives were met. Here are components ADE will strive to maintain as STEM continues to develop with the 21st Century Community Learning Centers grantees and their schools.

- Motivate students in grades 4-6 to take up STEM careers by encouraging them to work for math competency prior to 8th grade. ADE plans to track this through the supportive practice of surveying students pre- and post-program regarding their perceptions about their math.
- Boost the importance of inspiring students who might not otherwise follow a math or science path, including females, minorities, students with disabilities, etc. so they might realize their potential. This would be supported through referring students who may be overlooked to STEM programs. Competitive application can be counterproductive to reaching under representative groups.
- Relate programs to local and cultural variations, particularly for Native American sites. Building on the lessons of the STEM Clubs, ADE will incorporate cultural aspects into all activities, notably into student field trips. As a supportive practice, ADE plans a system where cultural education specialists review all curriculum and practices as well as the physical surroundings prior to STEM offerings.
- Provide students and their families with motivating STEM-related experiences to stimulate lifelong interest. This would be supported by relating the STEM Club curriculum to a community facility that students and families can access continually.
- Employ and/or engage instructors and teachers who are trained by qualified staff developers in inquiry-based learning. This would be supported by the practice of engaging STEM instructional staff with a combined background in science or math and education. STEM interest would build on a foundation of non-threatening inquiry-based experiences before more complex or challenging activities were offered. The goal is to increase the involvement of underrepresented populations. Without the foundation, children in these groups may self-select out.
- Impact the regular day school's ability to implement STEM. The supportive practice would be to gently ease the daytime classroom math and/or science teachers into out-of-school time STEM instruction by training them and giving them special technical support to conduct their own STEM classes.
- Provide experiences for business/industry, community organizations, educators, students and parents related to STEM and motivate them to expand in their various spheres of influence. This would be accomplished by host events that bring these diverse groups together to learn about strategically designed STEM events.

The ADE 21ST Century Community Learning Centers encourages districts to consider the practices that were developed and refined that led to successful program outcomes. ADE will continue to

encourage or even require future grantees to strategically plan for STEM in their schools in order to qualify for funding identified as STEM, rather than accept quick-solution offers or products simply based on the label: STEM.

REFERENCES

Afterschool Alliance (2013). *Defining youth outcomes for STEM learning in afterschool.* Washington DC: Afterschool Alliance.

Arizona Science Center. STEM Club and Camp Evaluation Reports:

Evaluating a 21st Century Community Learning Center summer enrichment program. (July 2009)

21st Century Community Learning Center STEM club and camp evaluation. (June 2010)

21st Centery Community Learning Center STEM club: Children and parent survey results. (Fall 2010)

21st CCLC STEM club pilot teacher evaluation. (December 2011)

STEM club pilot program. (Spring 2011)

Gerlach, Jonathan (4/11/2012) STEM: Defining a simple definition. NSTA WebNews Digest. Retrieved from: http://www.nsta.org/publications/news/story.aspx?id=59305

Hynes, Greene, & Constance (Fall 2012). Helping youth prepare for careers: What can out-of-school time programs do? *Afterschool Matters*,16,21-30.

Lyon, Gabrielle H.; Jafri, Jameela; St. Louis, Kathleen. (Fall 2012) *Afterschool Matters* 16, 48-57.

National Research Council. (2009). *Learning science in informal environments: People. Places, and pursuits.* Washington,DC: National Acadamies Press.

The After-School Corporation. (ND). *Science after school: How to designand run great programs and activities.* NY: TASC.

APPENDIX

STEM Club and Camp Curriculum Topics

Summer 2009	Engineering
	Physics
	Earth and Environmental Science
	Biochemistry
Summer 2010	Campfire Science
	Behind the Big Top: Uncovering the Secrets of the Circus
	Explorers and Treasure Hunters
	Mission to Mars
Summer 2011	Game Day
	Design a Creature: Habitat Adaptations
	CSI Mystery Festival
Summer 2012	Space Camp
To the Moon and Beyond	Launch
	Touchdown
	Space Exploration
	Moon City
Summer 2013	Lights, Lasers & Color
Kaleidoscope Science	Medical Mysteries
	Ph-antastic Physics
	Animal Adaptations
	Constructioneering
Fall 2012 & Spring 2011	Making the Band: An Exploration of Sound & Music
	Farming to Fuel: An Exploration of Biofuels
	The KEVA Challenge: Design & Build It!
	Lemonade Stand & Other Chemysteries: The Mysteries of Chemistry
	Where the Wind Blows: Energy from the Wind
Fall 2011	Architecture: Master Builder to Engineer
	Making the Band
	Chemysteries: Mysteries of Chemistry
	Design and Build It: Strength in Triangles
	Camping: Habitat Survival and Solar Energy
Fall 2012 and Spring 2012	What is a Desert
Celebrate Arizona	Geology of the Sonoran Desert
	The Power of the Sun: Solar Energy
	Food for Thought: Desert Plants
	Living Things: Desert Birds
	Living Things: Desert Animals

	Water on Earth: Water Cycle
	Water: How People Get it and Use it
	Shelter: Survival in the Desert
	Biodiversity: Our Human Footprint
Spring 2010	Puppets, Gizmos and Gadgets: What Makes them Work? Pyramids, Pulleys and Roller Coasters: An Investigation of Simple Machines
	Let's Fly a Kite: Materials, Structures and Textiles
	Energy Balls and Bulbs: An Exploration of Circuits
	Start Your Engines: What are Motors and How do they Work? Animals on the Move: What can we Learn from Animal Locomotion? From Shoes to Spaghetti: Experimenting with Design, Structure and Balance
	Final Project: Design and Build a Toy
	Final Project: School Toy Festival
	The Sonoran Desert
	The Sonoran Desert
	The Power of the Sun: Solar Energy
	Food for Thought: Desert Plants
Spring 2013	Get the Details on Dirt!: The Foundation of Our Food Wonderful World of Water: Sustainable Uses and Physical Characteristics
Seed to Savor	
	E is for Energy!: Sustainable Energy Exploration The Parts, Pieces and Purpose of Plants: Roots, Leaves, Seeds and More
	The Power of Pollinators: Birds, Bees and Other Bugs
	The A Team: Animals and Agriculture The Nutrition Behind Good Eats: Food Groups and Basics of Biochemistry Processing, Packaging and Preservation, Oh My!: Processed Foods
	A Tasty Proposition: Cooking and Eating
	Digestion and Metabolism: Break it Down Now!
Spring 2013	Stranded! What to Eat?
Legos of Life	Top Chef Smoothies
	Feel the Burn
	Discover DNA Monster Manual Lab and Monster Makeup
	Protein Bracelets
	Scorpion Dissection
	Venom! Lab
	Paper Proteins
	Busy Bones