Engineering Adventures Curriculum Development Grant

Final Report

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"I have one student in particular who has asked me about the project daily! She absolutely loves engineering, especially when it's oriented around helping others. It's been wonderful to see her excitement and self-discovery."

—*California Afterschool Educator*

Project

Summary and Goals

The *Engineering Adventures: Curriculum Development* grant awarded to Engineering is Elementary (EiE) by the S.D Bechtel Jr., Foundation advances and amplifies an earlier Bechtel-funded initiative that supported the creation and pilot testing of "Engineering Adventures," a novel engineering-focused out-of-school time (OST) curriculum. Building on the successful pilot test, the latest grant supports the EiE curriculum development team in developing new Engineering Adventures curriculum units and field testing the entire curriculum package.

During the initial pilot-testing phase, EiE staff identified a significant demand for STEM (science, technology, engineering, and math) curriculum among OST educators—in particular, curriculum that introduces children to engineering and inspires a new generation of engineers. Engineering Adventures units, written for children in 3rd through 5th grade, are designed to meet this need. The curriculum is specifically designed to present students with real-world engineering challenges and promote creative problem-solving.

The goals of the *Engineering Adventures: Curriculum Development* project include the following:

Unit development

- Drafting three new Engineering Adventures units
- Field testing five units (two from the previous grant, plus the three new units)
- Revision of units based on field test results

Unit Evaluation

- Conducting formative evaluation with both OST educators and children

Web Development

- Developing online elements that support the Engineering Adventures units
- Field testing of online elements
- Evaluation of online elements through focus groups

Unit Development

Unit Drafting, Field Testing, and Revisions

With each development cycle, the EA team learned more about best practices and critical design criteria for creating successful OST curricula. In this section, we present overarching findings, followed by in-depth discussions of the changes made to each individual EA unit during the revision process.

The EA team successfully completed drafting, testing, and revision of five Engineering Adventures units (listed in Table 1).

Table 1. Engineering Adventures Units Created and Tested Through this Grant

Title	Engineering Field	Setting
Hop to It: Safe Removal of Invasive Species	Mechanical	Australia/New Zealand
Bubble Bonanza: Engineering Bubble Wands	Materials	California, USA
To the Rescue: Engineering Aid Drop Packages	Package	Thailand
Shake Things Up: Engineering Earthquake Resistant Buildings	Earthquake	Haiti
Go Green: Engineering Recycled Racers	Green	Senegal

To create the first EA units (*Hop to It* and *Bubble Bonanza*), the curriculum development team drew from design principles that EiE proved successful for classroom-based elementary engineering curricula, while implementing modifications and new ideas based on extensive OST background research completed prior to the start of this grant. Field testing of EA units revealed several critical components are common to successful engineering activities both in-school and out-of-school. These include a focus on inquiry, incorporation of the engineering design process (EDP), and inclusion of hands-on activities. Testing also revealed additional design criteria critical to success in OST environments. These include the following:

- *Science explorations in the unit need to be clearly and concretely tied to the culminating engineering challenge.* Examples of science-focused investigations we have found to be successful in OST include exploring the exact materials that will be available for the engineering challenge and testing component parts of the technology to be created during the challenge.
- *Lessons must be structured to quickly allow children to engage in a hands-on way with materials.* Questioning and discussion prior to beginning the hands-on portion of the activity should be no more than five minutes long. During the hands-on part of the activity, kids should be given parameters to guide their explorations, but should have a degree of autonomy over what they are investigating. This structure is advantageous for educators as well, since their responsibility is refocused, allowing them to support (rather than direct) children as they investigate. This supportive role is one that most OST educators are already comfortable with.
- *The steps of the engineering design process should be made explicit throughout all lessons.* The critical thinking strategies and iterative problem solving reinforced by the EDP complement the types of social and 21st century skills often emphasized in OST, making the process particularly appropriate for this setting. First drafts of our units used the EDP as a backdrop and directed educators and kids to return to the EDP during reflection portions of each activity. This passive use of the EDP was not particularly effective. More recent versions of units employ the EDP in nearly all sections of a given activity. This usage has proven to help underscore the importance and utility of the process with children and educators.
- *The term "engineer" should be used as frequently as possible to deepen understanding of this vocabulary word.* Early versions of EA units used the verb "design" nearly interchangeably with "engineer". Testing revealed that introducing more than one new vocabulary word per activity confused children and in some cases barred them from fully engaging with the content. The EA team made the choice to highlight the terms "engineer" and "engineering design process" over all other vocabulary in each unit. Observations have indicated that this helps both educators and children deepen their understanding of the words and become more comfortable using them.
- *Engineering Journals need to include clear prompts and space for both writing and drawing.* For the most part, children in OST are not keen on writing extensively or in a manner similar to the way they are required to record thoughts in school. Engineering

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Journal pages need to include short, clear prompts for recording thoughts through writing or drawing.

- *Units must incorporate the "SAFE" activity criteria.* SAFE criteria include Sequential activities that encourage Active youth involvement, are Focused, and have Explicit learning objectives. A recent study of OST programs indicated these criteria are positively linked to social and academic outcomes[1]. EA units embed these criteria by including 6-10 activities sequenced to allow children to build upon discoveries made in previous sessions. All activities encourage active, focused, hands-on experimentation and engineering explorations. Additionally, all activities are written so that the steps of the engineering design process and the engineering goal are repeated over and over, making children's roles as engineers explicit.

After having written several EA units and having observed many of our lessons being implemented in OST programs, the team refined and clarified four beliefs and learning goals for successful engineering curricula in OST (Table 2).

Table 2. EA Beliefs and Learning Goals for Successful Engineering Curricula in OST

We believe kids will best learn engineering when they:	**Kids will learn that:**
engage in activities that are fun, exciting, and connect to the world in which they live.	they can use the Engineering Design Process to help solve problems.
choose their path through open-ended challenges that have multiple solutions.	engineers design technologies to help people and solve problems.
have the opportunity to succeed in engineering challenges.	they have talen and potential for designing and improving technologies.
communicate and collaborate in innovative, active, problem solving.	they, too, can be engineers.

Development of project belief and goal statements led to the creation of the following mission statement for Engineering Adventures:

> The mission of Engineering Adventures is to create exciting out-of-school time activities and experiences that allow all learners to act as engineers and engage in the engineering design process. Our goal is to positively impact children's attitudes about their abilities to engineer by providing materials uniquely appropriate for the varied landscapes of out of school time settings.

We will continue to apply the design criteria and keep these goals in view as we work to fulfill the project mission in developing future EA units.

1 Yohalem, Nicole & Shouse, Andrew. Linking Afterschool Programs and STEM Learning: Proceed with Caution.

Hop to It: Safe Removal of Invasive Species Testing and Revision

The *Hop to It* unit challenges kids to engineer a humane trap to catch a cane toad (an alien and potentially harmful invasive species) that has been let loose in the country of New Zealand. This unit was drafted in 2010 as part of a precursor proof-of-concept grant and was first released for field testing in the spring of 2011. The unit was tested with 10 summer camp programs and 40 afterschool programs.

Revisions to this unit were extensive and were informed primarily by EA staff observations during site visits along with educator feedback (written and in-person during focus groups held at the Museum) and quantitative data gathered through child post-assessments. *Hop to It* is subdivided into a number of subsections (called "adventures"); Table 3 includes a description of each adventure and summarizes specific feedback received along with changes made to address the feedback.

Table 3. *Hop to It* Unit Feedback and Revisions

Adventure 1 Cane Toad Invasion: A musical chairs game that modeled how cane toads take homes away from native animals.	Feedback	• Educators felt it did not give an urgent sense of 'invasion' or reflect the massive extent of the cane toad problem in Australia. • Musical chairs is seen as immature/not engaging for older children.
	Solution	• An engaging video was substituted for the game. The video can be viewed here: https://vimeo.com/user8227474/review/49886782/f27837d2ba. This video, which lets children see cane toads and hear Australians describing the toads' impact on the ecosystem are more compelling than any model. • Hearing from real scientists within the DVD proved a better match for older children in the group while still providing accessible information for young participants.
Adventure 2 Feeding Frenzy: A game designed to model the impact cane toads have on the food supply of native animals.	Feedback	• The game lasted too long and children got bored.
	Solution	• Because the new DVD inserted in Adventure 1 addressed the issues of invasive species impacts on food supply, this Adventure was cut from the unit.

Adventure 3 Cane Toad PSA: Kids create a public service announcement about the negative impacts of cane toads.	Feedback	• While children learned about some of the problems created by cane toads, they had not yet started to address the problem by creating traps. Thus, their PSAs only spoke to the invasive species problems, not the possible solutions.
	Solution	• The unit was reorganized with the PSA as the last activity in the unit. Making the PSA part of the culminating activity allowed kids to share information about the cane toad problem as well as their trap designs. What's more, parents and other children visit the program for the final design showcase, creating a built-in audience for the PSAs.
Adventure 4 Rube Goldberg: Kids create small Rube Goldberg machines that include components and ideas they could transfer to their trap designs.	Feedback	• Although the kids really enjoyed making Rube Goldberg machines (this was rated as one of their favorite activities in the unit), the lack of a direct link between this activity and the design challenge made the experience feel tangential.
	Solution	• The Rube Goldberg idea was incorporated directly into the design challenge by adding a length criterion—kids must be able to activate their traps from at least four feet away.
Adventure 5 Machine Scavenger Hunt: A scavenger hunt for simple machines they could use in their trap designs.	Feedback	• Kids were not able to make a direct link between the machines they identified in the classroom and mechanisms they could use in their own cane toad trap designs. • Kids didn't enjoy this activity, and it did not hold their attention for the full session.
	Solution	• This activity was removed from the unit.
Adventure 6 Designing Traps: Kids began designing their own cane toad traps.	Feedback	• Kids generally enjoyed this activity. Some of the materials were difficult to cut or manipulate. • Kids wanted to actually catch something in their traps.
	Solution	• Materials that were easier to cut and manipulate were included. • The length criterion was included to enhance the Rube Goldberg aspect of the challenge. • A wind-up toad toy was included so kids could actually catch something in their traps.

Adventure 7 Improving Traps: This continuation of Adventure 6 allowed kids to continue designing, testing, and improving.	Feedback	• Most kids needed this time to continue working, but some groups did not (some were almost done, others were still at square one).
	Solution	• Suggestions for having groups share their designs were included. This helped groups learn from each other and is particularly valuable to groups that are struggling.
Adventure 8 Design Showcase: Kids present their work in whatever format the educator has chosen (science fair, show, jigsaw, etc.)	Feedback	• The EA team intentionally left a good deal of flexibility in the structure of the showcase (suggesting it might be run like a science fair, groups might present one at a time, or as a jig-saw). This level of openness left educators and kids wondering about the point.
	Solution	• The activity previously labeled "Adventure 3 (Cane Toad PSA)" was incorporated and framed as a central feature of the showcase. • Through the PSA, kids were given the chance to share all that they learned about the cane toad problem, as well as their own trap designs.

After all these revisions were completed, a revised version of the *Hop to It* unit including six adventures and the new context-setting video) was made available for the public to download beginning in the fall of 2012 (www.eie.org/engineeringadventures/units).

Bubble Bonanza: Engineering Bubble Wands Testing and Revision

This Engineering Adventures unit challenges kids to engineer bubble wands to meet a goal of their own choosing (blowing tiny bubbles, blowing multiple bubbles, blowing huge bubbles, and so on.). The *Bubble Bonanza* unit was field tested during the fall of 2011. The unit was tested with 14 summer camps and 28 afterschool programs.

Because the *Hop to It* unit had previously gone through several rounds of testing, the team was able to apply the critical design criteria developed through that testing in the first iteration of the *Bubble Bonanza* unit. During preliminary testing specifically for the *Bubble Bonanza* unit, educators reported that kids were inherently fascinated with bubbles. Educators noted that many OST sites were not well-equipped to handle the messiness that comes with using bubble solution, however—alerting us that we needed to include suggestions to would mitigate mess.

Table 4 includes a description of each adventure (i.e., activity) in the *Bubble Bonanza* unit and summarizes feedback from the field tests as well as the revisions we made in response to the feedback.

Table 4. *Bubble Bonanza* Unit Feedback and Revisions

Adventure 1 Bubble Brainstorm Kids experiment with bubbles, creating a list of things bubbles can and cannot do.	Feedback	• This lesson was fun for kids and a great way to activate prior knowledge about bubbles.
	Solution	• Few changes were made to this lesson
Adventure 1a Stop the Pop Kids experiment with ways to stop bubbles from being popped when they come in contact with another surface.	Feedback	• The explorations were a beneficial way for children to further push their knowledge about what bubbles can and cannot do. • The knowledge gained, however, was not essential for the culminating challenge.
	Solution	• Since the explorations in this activity were not found to be critical, the adventure was made optional.

Adventure 2 Not Round Bubbles Kids experiment with different wand shapes to see if it is possible to blow a not round bubble.	Feedback	• Originally, a great deal of focus was placed on the materials kids could use to create their wands. • While the exploration with different materials was useful, kids did not reach a deep level of understanding about material properties.
	Solution	• The number of materials available for making wands was limited to just two, allowing for a deeper level of comparing and contrasting.
Adventure 3 Best of Bubbles Kids try to accomplish various bubble tricks using different wand materials.	Feedback	• Suggesting eight different bubble tricks was too chaotic. • Some of these tricks resulted in big messes!
	Solution	• The number of bubble tricks was cut to four and the messiest tricks were removed from the activity
Adventure 4 Creating Bubble Wands Kids engineer their own bubble wands using materials from previous adventures.	Feedback	• Kids easily created their wands, but with few criteria, some kids completed their designs very quickly.
	Solution	• A new criterion was added: Kids would need to combine at least three materials in their wand. This step increased the materials engineering thinking required to complete the challenge.
Adventure 5 Improving Bubble Wands Kids improve their bubble wands.	Feedback	• For children who created very simple designs, this lesson was unnecessary.
	Solution	• Because an additional materials criterion was incorporated in the previous activity, this lesson was a valuable chance for children to troubleshoot and perfect their designs.
Adventure 6 Engineering Showcase In this activity kids put on a bubble show for visitors.	Feedback	• Many field sites took very creative approaches to the bubble show, inviting younger afterschool participants to attend or putting the show to music.
	Solution	• Because the bubble show proved to be so engaging for observers, we added to the activity the suggestion that materials be available for observers to engineer their own bubble wands.

The *Bubble Bonanza* unit was made available on our website at the beginning of June, 2012 (www.eie.org/engineeringadventures/units).

To the Rescue: Engineering Aid Drop Packages Testing and Revision

This unit challenges kids to design aid packages—packages that can be dropped from an airplane or helicopter to help survivors after a disaster. Kids must develop a design that will protect the supplies inside and also communicate the package contents to the people who find it. The *To the Rescue* unit was originally field tested during the spring of 2012. The unit was tested with 10 summer camps and 32 afterschool programs.

The content of *To the Rescue* changed dramatically after we received feedback from field testers. While the engineering principles and pedagogy were solid, the unit initially introduced two content themes: the physics of protecting packages that will be dropped from a height and biomimicry (human-created technologies that take inspiration from nature). Kids were introduced to the idea of natural packages (fruit rinds, animal shells, etc.) and asked to use these natural "packages" as models for their own human-made aid package designs. Educators expressed (and observations confirmed) that the biomimicry connection was difficult for children to understand and apply to the packages they designed. For this reason, the unit was revised to focus on the physics of protecting packages from impacts.

Table 5 describes the activities that make up *To the Rescue* and summarizes feedback from the field tests as well as revisions made in response to the feedback.

Table 5. *To the Rescue* Unit Feedback and Revisions

Adventure 1 Aid Drops and Biomimicry Kids model how supplies are delivered during aid drops and are introduced to biomimicry through a game where they must match engineered packages and natural packages.	Feedback	• Kids enjoyed modeling aid package delivery (drops) and understood the challenge of protecting things that will be dropped out of planes. • The concept of biomimicry was difficult for many kids to understand and connect to, especially if they had no prior experience with the natural or engineered items on the cards.
	Solution	• The biomimicry component was removed from this lesson and ultimately from the entire unit. (Biomimicry and engineering may eventually become a stand-alone EA unit.) • To underscore the ultimate engineering challenge and get kids doing hands-on inquiry right away, the activity called for kids to test soft and hard packaging right off the bat. • After significant testing, the team identified farfalle pasta as the optimal material to place inside the packages. Successful packages will keep the pasta from breaking.

Adventure 2 Incoming Kids perform test drops of three naturally inspired packages and see how well they protect what is inside.	Feedback	• While kids enjoyed testing the three naturally inspired packages, they did not necessarily make the connection to biommicry. There were also timing issues, with some tests taking much longer than others. • The success indicator for this activity was a ball of clay that showed an indentation when dropped in a rough way. Kids found it hard to gauge accurately whether the ball had been damaged.
	Solution	• The biomimicry component of this activity was removed. Kids still tested three design elements (wings, canopies, parachutes) presented as possible ways to slow the fall of packages. • The activity was modified to include suggestions for ways the educator could rotate children through testing stations to address timing difficulties. • The pasta “success indicator” identified in Adventure 1 was substituted for the clay indicator.
Adventure 2a Packing an Aid Package Kids decide as a group what the most important items are to pack in an aid package.	Feedback	• At some EA sites, educators expressed that the discussions resulting from this adventure were incredibly thoughtful and interesting to te kids. • Some of the activity’s set-up logistics (having kids model the packing of aid supplies) proved difficult.
	Solution	• Logistics that proved difficult were eliminated, allowing kids and educators to focus on the main points of the activity—what are the most important things to include in an aid package? • Kids were asked to make a pamphlet that serves as a record of their decisions. They include this pamphlet in the package they present in Adventure 6.
Adventure 2b Transformer Packages Kids design a way for their packaging to be used as a game or toy after the aid has been received.	Feedback	• Some educators expressed that, much like Adventure 2a, this activity really captured their kids’ imaginations. The kids enjoyed creating their transformer packages. • Even at sites where kids truly enjoyed this lesson, educator expressed concern that the adventure was an outlier in terms of the flow the unit.
	Solution	• In one of the most difficult decisions the curriculum team made, this adventure was removed. Because it was so successful, the team is strongly considering creating an entire EA unit around the idea of engineering toys from packaging that would otherwise be discarded.

Adventure 3 Display Kids design a label for their packages so they will easily be seen upon landing.	Feedback	• Most kids had fun creating labels for their packages, but it was not clear that they understood the reason for doing so—that aid packages must be easy to find and packaging must communicate what is inside.
	Solution	• The team clarified the language describing the main goals for the labels both indirections for the educator and questions directed at kids.
Adventure 4 Design an Aid Drop Package Kids began designing their own aid drop packages.	Feedback	• The clay balls originally included to serve as indicators of how well the package protected its contents were difficult for children to score.
	Solution	• The pasta introduced as a new indicator allowed children to simply note whether pasta broke or now. This proved to be an easy way for children to assess the success of their packages.
Adventure 5 Improving an aid Drop Package This continuation of Adventure 4 allowed kids to continue designing, testing, and improving.	Feedback	• Because kids were asked to think both about how well their package protected its contents and also how well it displayed the package, most groups needed this lesson time to continue working on their designs.
	Solution	• Few changes were made to this adventure. Wording was tightened up, particularly in the questions asked of participants.
Adventure 6 Engineering Showcase In this activity kids present their work in whatever format the educator has chosen (science fair, show, jigsaw, etc.)	Feedback	• While the kids really enjoyed the unit, it was a bit anti-climactic to drop their improved packages. Educators suggested we might ramp up this final drop by including something that could possibly be messy or otherwise create drama.
	Solution	• Water balloons were included as an optional package insert; groups that prefer to work only with pasta indicators are allowed to do that, too. Having a choice about how to evaluate your design is an important part of the challenge!

The Engineering Adventures unit *To the Rescue* will be made publicly available for download at the conclusion of this grant (in early February 2013).

Shake Things Up: Engineering Earthquake Resistant Buildings **Testing and Revision**

This unit challenges kids to engineer model buildings that withstand a 7.0 magnitude earthquake simulated using "shake tables." Field testing of S*hake Things Up* began in the spring of 2012. The unit was tested with 12 summer camps and 30 afterschool programs.

Shake Things Up calls for each group of kids to build their own shake table, and this aspect of the unit was an immediate hit that also helped kids become invested in the testing process. Educators told us that kids also found the engineering challenge—designing earthquake-resistant structures—engaging. Changes to this unit were fairly minor, focusing primarily on revising vocabulary to be easily understood, and removing or replacing materials that were found to be difficult for kids to manipulate.

Table 6. *Shake Things Up* Unit Feedback and Revisions

<table>
<tr><td rowspan="2">Adventure 1
A Shaky Situation

A short video presents problems related to the 2010 earthquake in Haiti, then kids construct their model shake tables.</td><td>Feedback</td><td>• The video was well received.
• An additional article about the earthquake was difficult for children to read, and the lesson asked them to mark or highlight too many things within the article.
• The first versions of the shake tables included ping pong balls as rollers. The ping pong balls were difficult for kids and educators to corral—they came loose easily—and the directions for making the table were difficult for kids to follow.</td></tr>
<tr><td>Solution</td><td>• Shake tables were modified to include small cylinders as rollers. Cylinders do not bounce if they come loose from the shake table.
• The article was shortened. Instead of asking kids to make notations on the article, the educator follows up with some reflection questions.
• Shake table directions were changed to show kids their end goal by including a picture of the finished table, and clearer pictures were included for each construction step.</td></tr>
<tr><td rowspan="2">Adventure 2
Building Skeletons

Kids are introduced to the idea that buildings have beams or supports inside of them. Kids create their own building units (model buildings).</td><td>Feedback</td><td>• The building units were difficult for the kids to create.
• Cutting the pipe cleaners and straws in half required more precision than initially anticipated. Because the building materials were not cut precisely, the units built from these materials were unstable.</td></tr>
<tr><td>Solution</td><td>• The selection of building materials was modified to use coffee stirrers instead of straws and entire pipe cleaners were used instead of halves. This eliminated the need for any precision cuts.
• The team added a tip for educators working with very young children: Teachers might want to insert the pipe cleaners into the straws themselves.</td></tr>
</table>

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Adventure 3 Stop the Slide Kids are introduced to the idea of building foundations and asked to design ways to stop their building units from sliding during an earthquake.	Feedback	• Kids did not find this activity to be much of a challenge—inserting just a few toothpicks or brass fasteners into the floor of the building unit stopped it from sliding. • The materials used (particularly the foam) were not always good models for materials used to create real building foundations.
	Solution	• Rather than trying to draw a direct link to building foundations, the team rewrote the lesson to express only the goal of preventing the building units from sliding off the shake table. • To make the activity more challenging, an additional goal—using as few materials as possible—was introduced. • Comparisons between the model materials and real building materials were removed.
Adventure 4 Getting Braces Kids design a way to stop their building units from wobbling.	Feedback	• Some kids used lots and lots of materials to stabilize their buildings. However, engineering often involves thinking about ways to minimize the materials used in a design.
	Solution	• A materials goal was introduced—kids are asked to stabilize the units using fewer than 10 items.
Adventure 5 Design Kids choose a building they will create as their earthquake resistant structure.	Feedback	• Kids found the activity engaging. • Because there was no materials limit, some groups used many more materials than they needed.
	Solution	• A materials limit unique to each building choice was introduced.
Adventure 6 Improve Kids improve their earthquake resistant structures.	Feedback	• Few groups were able to generate a list of suggested building codes. Educators noted this activity required pulling information from all previous adventures, which can be difficult in the OST setting.
	Solution	• The generation of a building codes list was parsed out across all adventures. For example, after completing Adventure 3, which focuses on attaching the building unit to the ground, kids were asked to make recommendations for this aspect of earthquake engineering.
Adventure 7 Engineering Showcase Kids present their work, create a model 'city' and shake all their structures.	Feedback	• When groups had difficulty creating a list of building codes in Adventure 6, they also had difficulty presenting the portion of the showcase intended to focus on building codes.
	Solution	• After the task of creating and recording building codes was distributed throughout the entire unit, this piece of the showcase went more smoothly.

Shake Things Up will be made publicly available for download at the conclusion of this grant, in early February 2013.

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Go Green: Engineering Recycled Racers Testing and Revision

In this unit, children use materials that would normally be thrown out or recycled to engineer a toy race car. The *Go Green* unit was first field tested in the summer of 2012. To date, the unit has been tested with 15 summer camps and 11 afterschool programs. Final field testing will start in February of 2013 and finish in May.

Initially, the main design challenge for *Go Green* was engineering wheels that would make race cars roll. During early testing, the curriculum team found that this challenge was too difficult. Revisions to this unit primarily involved supporting children and educators in engineering wheels that work.

Table 7. *Go Green* Unit Feedback and Revisions

Adventure 1 Let's Get Rolling Kids sort materials that would otherwise be thrown away by how they might be used in their cars.	Feedback	• Sorting the materials into bins according to their possible function took too long and was not captivating for kids. • It was time consuming for educators to create the test track.
	Solution	• The activity was revised so that groups worked together to create the test track. This structure gets the kids invested in the tool they'll be using for testing, and also eliminates the need for the educators to create the track. • The material sorting activity was shortened and moved to Adv 2.
Adventure 2 Wheeling Around Kids are shown the track they'll test their racers on. They can then begin designing their cars.	Feedback	• We anticipated kids would have difficulties engineering wheels that worked—in fact, this difficulty was an intentional part of the lesson. Some educators and kids found the adventure frustrating, though.
	Solution	• The focus of the activity was changed so that kids were looking at matchbox cars to identify parts, and then sorting materials according to possible functionality. • Kids began to create their cars, but did not yet need to achieve fully functional wheels.
Adventure 3 Reinventing the Wheel Kids focus specifically on the wheel variable, changing the size and number of wheels on their car.	Feedback	• Because many kids had such difficulty getting wheels to work (even using the template provided), it was a big leap to jump to the idea of testing wheel variables. • Kids could not create car designs that would allow them to easily pop different wheels on and off to compare different types of wheels.
	Solution	• During the testing planned for spring of 2013, the team will include two different types of wheel templates, which we hope will increase success levels. • The activity is now structured so that, rather testing multiples types of wheels, each group shares information about the specific wheels they test.

Adventure 4 Create Kids begin designing their recycled racers. The idea that they can power their racers using air is introduced.	Feedback	• For kids who did not yet have working wheels, introducing air as a way to power the racer was difficult. • Kids had trouble figuring out how they could use the balloons to power their racers.
	Solution	• The added structures to previous lessons are intended to minimize wheel difficulties. • New images are included in the journals to give kids more ideas about how they could use air power.
Adventure 5 Improve Kids perfect their air power system.	Feedback	• Kids enjoyed the prospect of including air power systems. In the first draft of this adventure, the ramp was removed from the track, making air power the only mechanism for moving the cars.
	Solution	• In the current draft of the unit, air power and a ramp are combined to power cars, allowing designs to go farther than if air power alone was used.
Adventure 5a Art of the Car Kids are given the chance to decorate their recycled racers.	Feedback	• Kids enjoyed being able to personalize their cars. • Kids who were still struggling with their car designs found this activity gave them more time to perfect their cars.
	Solution	• This lesson changed very little from the initial iteration.
Adventure 7 Engineering Showcase Kids present their work and participate in the recycled racer rally.	Feedback	• During the Recycled Racer Rally, kids were asked to choose one race to participate in: Either "go fast," or "go far". • Many educators did not separate the races into these two categories, preferring to focus on the "go far" race, which is easier to measure.
	Solution	• The "go fast" race will not be included in 2013 pilot testing. • Kids can choose to participate in either the sail-powered or the balloon- powered race. • Both races are written with a focus on achieving your personal best.

After spring 2013 field testing, the unit will be revised and made available for download.

Assessment and Analysis

Because the Engineering Adventures curriculum is still in development, evaluation efforts have focused on formative evaluation. The data collected through formative evaluation are generally considered preliminary—data are collected from children who are experiencing different versions of a curriculum as it is undergoing revision. Formative evaluation is a tool for improving the product—it is designed to first and foremost serve us in our revisions of curricula and provide a nuanced understanding of how to alter the curriculum for the better.

Some formative evaluation tools used as a part of this grant provide feedback on specific units and adventures, allowing us insight into facilitation and implementation of the experience. Other tools result in data that give us an understanding of trends in the afterschool environment and in child attitudes and conceptions (as well as misconceptions). All findings influenced revisions and further development. Findings from the evaluation of the Engineering Adventures program are discussed below.

Educator Feedback

The feedback we have received from educators who have used Engineering Adventures units confirms that the units are of high quality and enjoyable for kids in OST programs. Educators tell us they would be likely to implement more Engineering Adventures units in the future.

We asked educators to rate the quality of the unit being tested on a scale from 1 (poor) to 7 (excellent). The average rating was at least 5 for each unit throughout the development process. These routinely high ratings are encouraging for continued curricular development, suggesting educators value the EA activities.

We also asked educators, “Are you likely to teach this unit again?” and their answers provide more useful insight about that changes made during the revision cycle were effective. Figure 1 presents educator responses to this question for each unit’s first and current iterations.

Educators were overwhelmingly positive about repeatedly facilitating EA units. Only a small percentage of educators were not interested in teaching the units again, and most of these cited either 1) problems that the EA team has a limited ability to fix or 2) their desire to teach other EA units.

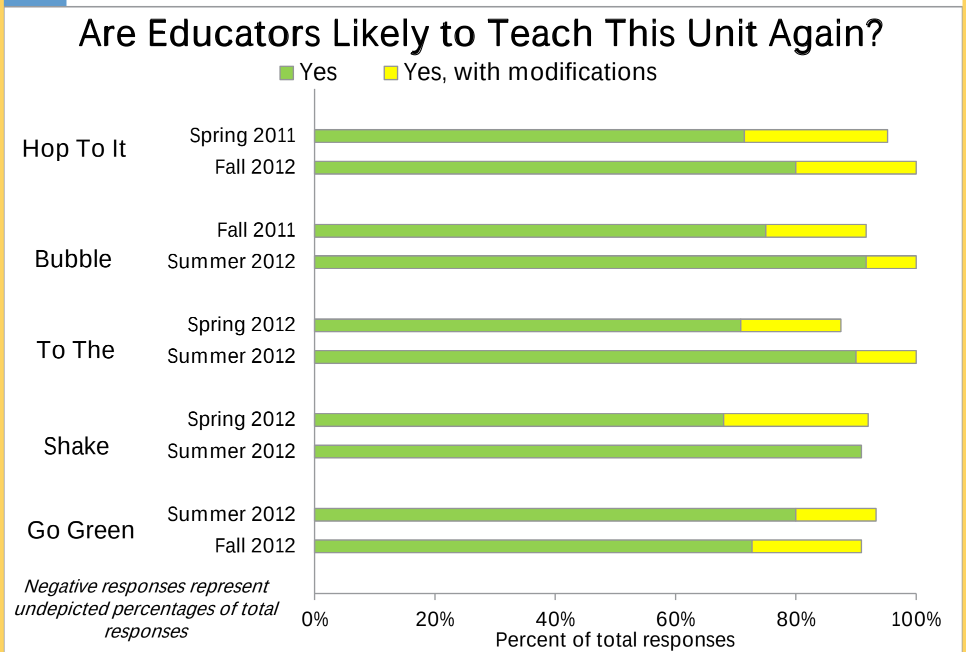


Figure 1. Are Educators Likely to Teach This Unit Again?

Some educators indicated they would like to teach a unit again, but only if modifications are made Suggested modifications were either 1) to address specific problems (issues with the "biomimicry" piece present in the early version of *To The Rescue*, which has since been removed) or 2) to address general problems (usually having to do with time available able to spend on Engineering Adventures. The team has addressed time constraints in some units by consolidating adventures, marking adventures as optional, or removing them entirely).

For nearly all units, we saw a noticeable improvement in educator responses from the early units to the later, more developed versions of the units. The proportion of educators who said they would not reteach a unit, or would reteach the unit only if it were improved decreased as the units were developed. And as units were developed and improved, the proportion of educators saying they would likely reuse the unit without modification increased. The only unit for which these trends did not apply is is *Go Green*: *Recycled Racers* which is still undergoing revision and testing through spring of 2013.

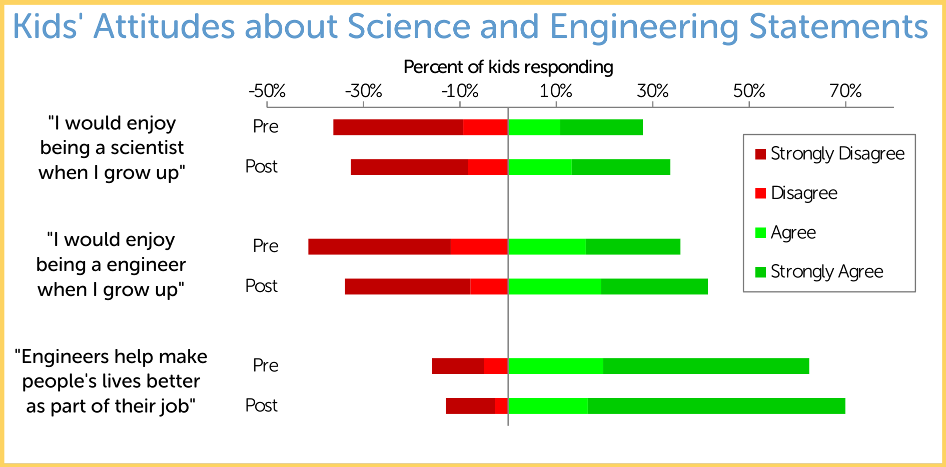
Engineering Attitudes Survey

Engineering Adventures child participants were asked to complete an "Engineering Attitudes" survey (see Table 8, below). This survey includes a list of 12 statements about science and engineering; children are asked to rate their agreement with each statement) both before and after completing the EA unit. The post-survey also features a very short open-ended response where children are asked to write about their favorite and least favorite parts of the unit. Analysis of the Engineering Attitudes survey administered to children as part of the field testing process indicates that children are learning about engineering and gaining confidence in their ability to successfully engineer.

Table 8. Engineering Attitudes Survey Statements

#	Statement
1	I would enjoy being a scientist when I grow up.
2	I would enjoy being an engineer when I grow up.
3	I would like a job where I could invent things.
4	I would like to help plan bridges, skyscrapers, and tunnels.
5	I would like a job that lets me design cars.
6	I would like to build and test machines that could help people walk.
7	I would enjoy a job helping to make new medicines.
8	I would enjoy a job helping to protect the environment.
9	I would like a job that lets me figure out how things work.
10	I like thinking of new and better ways of doing things.
11	I like knowing how things work.
12	Engineers help make people's lives better as part of their job.

Statistical analysis of children's responses to this survey shows that changes made over the development of EA units have resulted in a curriculum that better addresses its goals. During the summer 2012 testing season, children responding significantly more positively on post-tests than on pre-tests with respect to four of the statements in Table 8.



Presented below are responses for the statements that most closely address the goals of improving attitudes about engineering professions and kids' self-efficacy to be engineers

Neutral responses:
#1 "I would enjoy being a scientist…" Pre- 35.82% Post- 33.68%
#2 "I would enjoy being an engineer…" Pre- 22.80% Post- 24.74%
#12 "Engineers help make people's lives better…" Pre- 21.78% Post- 17.12%

Figure 2. Kids Attitudes About Science and Engineering Statements

(Statement #1:t=-2.572, df=476, p=0.010; Statement #2: t=-3.099, df=467, p=0.002; Statement #12: t=-3.037, df=476, p=0.003). Following participation in EA, children are more likely to agree with these statements about science and engineering. Statement #4, “I would like to help plan bridges, skyscrapers, and tunnels,” also showed significance but does not as closely align with EA’s stated goals.

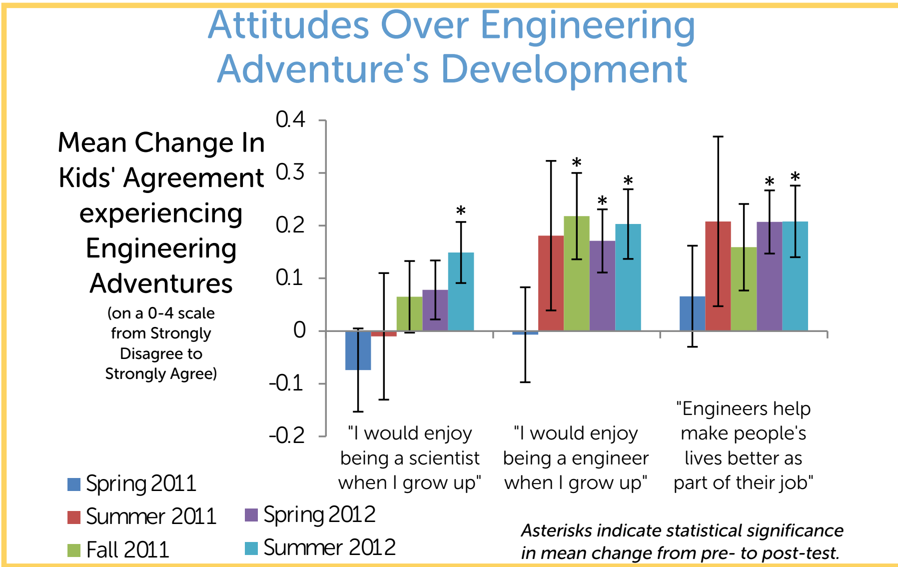


Figure 3. Attitudes Over Engineering Adventures Development

Early in the development of EA, statements did not show significant improvement, but children’s responses over the life of the project surface as significant in more recent testing seasons. As suggested by the graph of the mean changes in children’s responses, the EA team has honed the curriculum in such a way that units that include the critical components identified by the EA team show significant improvement in children’s attitudes.

The most notable improvement in this graph occurs between the spring 2011 and summer 2011 testing seasons. This leap (and the subsequent leveling off in mean change) suggest the lessons we learned from the spring 2011 test of *Hop to It*, and resulting changes we implemented, were extremely important in refining the curriculum to better address EA’s goals. The alteration to the curriculum that seems most likely to have caused this improvement is the extensive changes to language regarding engineering for all EA units. The team consciously replaced the word “design” almost exclusively with the word “engineer” when referring to the actions kids take. We feel this increased precision in vocabulary likely played a large role in the noticeable (and in more recent iterations, statistically significant) improvement in children’s attitudes about their ability to participate in engineering.

Children participating in EA were also asked whether they would like to do another Engineering Adventures unit. Their responses, presented in Table 9 below, indicate that students are generally engaged in the unit and interested in similar experiences. Students' responses to *Go Green*, suggest that further improvement is needed to make this unit more engaging. The unit was recently revised and will be tested during the spring of 2013.

Table 9. Would Children Like To Do Another EA Unit?

Unit	Yes	Maybe	No
To the Rescue	44.87%	20.51%	34.62%
Shake Things Up	40.18%	22.32%	37.50%
Go Green	34.15%	21.14%	44.72%

Although these responses are encouraging, they should be interpreted with the following caveats. 1) The question about completing another EA unit is the final question on the form, meaning that children may be feeling test fatigue by this point. 2) More importantly, children complete the form on the final day of the Engineering Adventures unit, meaning that student responses may reflect more on their engagement and enjoyment of that particular day of the unit than on the unit as a whole.

Children's Work

One way we assess Engineering Adventures' learning goals is by looking closely at children's written work. The Engineering Journals provided with each EA unit allow insight into how children think about the units. Our analysis of students' journals shows that children are indeed using the engineering design process to help them solve problems.

Qualitative analysis of *Hop to It* journals indicates strong use of the engineering design process. Many children speak with authority about their projects and exhibit deep understanding. Discussing how her trap works, for example, one child writes "Our trap works by pulling a string and trapping the cane toad inside. We improved it by using the stick to pull down the box and we added tape to the sides of the box to keep it together." She and her group made a specific improvement to their design based on testing they had done.

For the *Bubble Bonanza* unit, we examined journals both qualitatively and quantitatively, by coding and analyzing children's writing and drawing in journals from fall 2011 and spring 2012 field tests. In particular, we looked at the work children did while planning, creating, and improving their solutions to the design challenge.

The results of these *Bubble Bonanza* analyses were similar to those from *Hop to It*. Children recorded their knowledge about their projects on a deep level and were genuinely engaged in engineering. The children's designs also met their stated goals (90.0%, n=80), and their goals were quite realistic based on what they had learned from their explorations of the properties of bubbles (94.3%, n=88).

Children developed a variety of solutions to the design challenge, reinforcing the conclusion that the challenges are open-ended. And in improving their bubble wands, many children showed that they had learned from testing and altering their designs, and that they understood the constraints imposed by the materials and the properties of bubbles (34.5%, n=58). While not all children improved in this meaningful way, they were exposed to the process and had the opportunity to learn from peers in the showcase.

Figure 4 below provides an example of the important changes that children can make as the move from the "create" step to the "improve" step of the engineering design process. To engineer an earthquake-resistant building, this child changed both his design and the materials used (straws with pipe-cleaners at first, then popsicle-sticks as the primary material for bracing and a soft roof made from foam pads). By testing the initial design and responding to the results, this child demonstrated many of the learning goals of EA, including using the engineering design process to solve a problem. The child also shows a talent for designing and improving technologies.

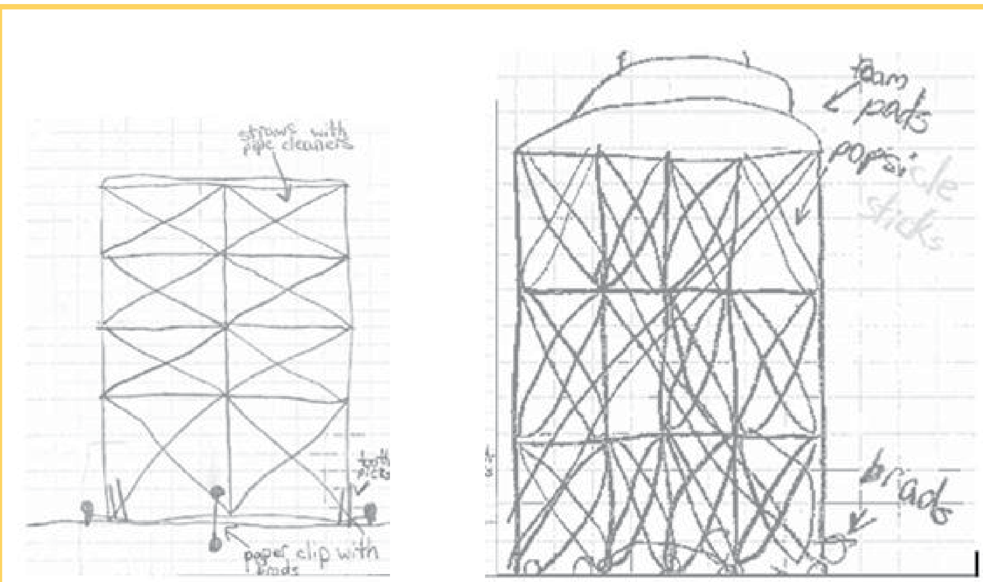


Figure 4. Plans for Earthquake-Resistant Apartment Building Model (Create step on left, Improve step on right)

Implicit evidence that EA is helping children learn about use of the engineering design process is reinforced by a review of the more explicit sections in student journals, where children reflect on their experiences. Figure 5 shows how a child uses the lens of the EDP to consider a group decision during the *Shake Things Up* unit to use toothpicks to secure the building.

Whether children understand how to apply the engineering design process outside of EA is beyond the scope of the data we can gather from engineering journals, but the many examples of children effectively utilizing and discussing the steps are very encouraging.

Showcase Observations

Some children are averse to writing down their ideas; other children work with educators who chose not to implement the journaling aspect of EA. For these situations we developed a protocol to assess student understanding of the unit content—a protocol we used during observations of the Engineering Showcase, the final adventure in each unit. The Showcase was included in the curriculum to give children the opportunity to share with others what they have learned about the technologies that they have engineered in the design challenge. This activity therefore provides a rich opportunity to access children's learning outside of their written work.

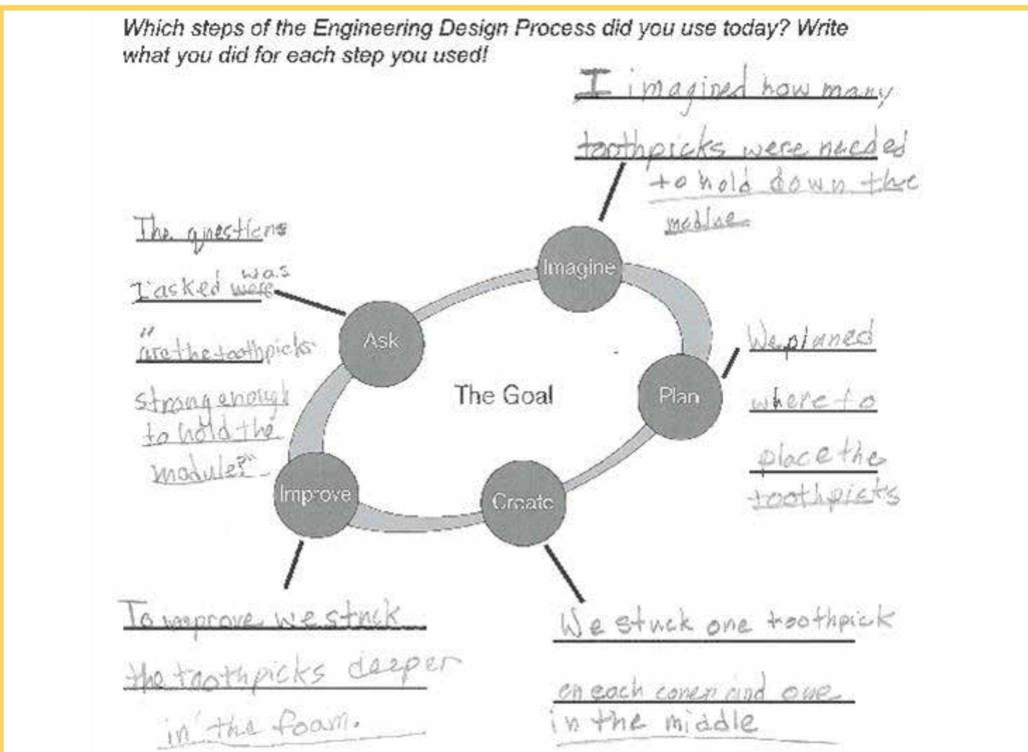


Figure 5. Child Describing Use of the EDP

When evaluators used the showcase protocol at a *Bubble Bonanza* site during summer 2012, two trends were apparent. First, the children come up with very diverse solutions to the problem—a finding that reinforced what we had seen in observations and in journals. Here's an excellent example straight from protocol notes:

"A girl produces her rather different design for producing small bubbles—a plastic tube with decorative pipe cleaners wrapped around it and a piece of wire mesh covering one end, taped down. On testing, the girl submerges the wire mesh end, and takes it out, then blows through the end of the tube. The tape has fallen off, so a large bubble is produced from the side of the wire mesh that has come loose. She tries again, holding the wire mesh tightly against the tube, and many, many small bubbles/foam are indeed produced. [Observer] asks about the tape, and how she might improve it. She replies that it fell off in the solution, and that maybe wrapping the mesh in wire would secure it better. [Educator] suggests rubber bands, and the girl agrees that this, too, would be worth trying. [From the next child, a group member of the first], a similar design too is demonstrated, this time with a hex-nut lodged in one end of the tube instead of the wire mesh. The goal was to produce lots of small bubbles quickly, and the hex-nuts' narrowing of the tube's end does indeed make this happen."

A fall 2012 *Go Green* showcase featured similarly diverse solutions to the design challenge. Children built their racers using a variety of materials and forms for the sails and car bodies. One group in particular was proud of having used half an egg crate for the body of the car—a design choice that was radically different from the various small boxes used by the other groups. Some groups used sails made from bent—rather than flat—pieces of paper or, instead of using light, delicate materials like tissue paper, combined multiple materials to make a sturdier, less-flimsy sail.

In designing wheels, however, all of the groups defaulted to an almost identical setup using a wooden dowel and two blank CDs for the axle and wheels. Based on this outcome and other observations of many other groups suggesting students copy what works for everyone else, we have revised *Go Green* so the activities will better help students explore and understand how to come up with their own designs for wheels.

The second major trend apparent in these showcases is that children talk easily about the solutions they engineer: how the technologies they have constructed work, their reasons for using particular materials, the challenges and excitement of the design process, and their plans for future improvement. Here's an example drawn from evaluator observations in which a pair of girls are heard talking about the problems they faced in the design process and how they creatively overcame the issues:

“Their goal was to make ‘big huge bubbles,’ but the wand seemed too flimsy to effectively give the bubbles structure. They describe how they originally just had a ring of wire, and the bubble solution wouldn’t stick to it, and talked about how at one point they used the wire mesh held over the wire to submerge the wand, then removed the mesh once [the wand was] out of the solution and the solution then stuck to the wire.”

In the *Go Green* showcase mentioned above, a boy from the group that built the egg-crate racer explained that the using the egg-crate had actually created some problems, as the air that fanned the sail of the racer was able to pass right through the open spaces in the egg-crate. To compensate for this problem—and to provide a more rigid surface for the air to hit—the boy’s team filled the body of the racer with paper towel. This solution, however, ended up moving their mast too much, so the boy recommended—covering the holes in the crate with tape.

Meanwhile, another group built a racer with a sail that simply sagged as soon as air hit it. At first, one child suggested “more weight on the bottom? No, nevermind . . .” then paused to think before deciding that a better improvement would be to add more tape to the sail.

Still another group built a racer using a very large, long box as the body but with this design, they were able to move the racer only when it was started from a ramp. And each time they were able to move the racer, one of the rear wheels would inevitably fall off. When asked about their experience, one team member said this wasn’t an issue of engineering but that “teamwork was a problem.”

Overall we saw that children were able to be thoughtful and reflective about their experiences. We conclude that the Engineering Showcases provide a great opportunity to access this evidence of students’ understandings.

Unit Evaluation Conclusions

The EA team has made a great deal of progress in developing and refining instruments for evaluating engineering learning and attitudes in OST. Through this process, we have learned several key lessons:

- Just like kids in formal education settings, kids in OST environments develop more positive attitudes about engineering and related careers when they engage in authentic engineering activities. Development of positive attitudes is bolstered when students can explicitly identify things they already like to do (such as inventing and problem-solving) as engineering.

- Participating in engineering is an engaging process for children. By providing multiple entry points including a genuine context, hands-on exploration of materials, and an exciting design challenge, we can scaffold students' learning, giving them the necessary knowledge and skills to be successful in the challenge.
- Kids come up with ideas and have legitimate engineering experiences as they work through a design challenge–although they may not be willing to write down these ideas and experiences. Kids develop deep knowledge and confidence, and they are generally able to express this in some form, whether written or verbal. The challenge for evaluators is accessing and interpreting these understandings.

Very few engineering-oriented OST instruments exist, and very little research on and evaluation of engineering education has been conducted, so the development of Engineering Adventures research instruments is breaking new ground. We look forward to continuing our refinement of the instruments developed so far—and also creating and testing new forms of evaluation where appropriate. We plan to share our instruments and reports with other educators with the goal of strengthening knowledge about STEM learning in OST across the entire field.

Development and Testing of Online Elements

In addition to developing the EA units, the curriculum development team developed supporting online elements and posted them to the project website (http://www.engineeringadventures.com, username: Guest, password: guest). Features of the EA website include the following:

- An interactive posting board where educators can build a community and guide conversations with kids in their program
- An incentive program in which kids receive electronic badges related for completing activities
- Supporting videos, games, and websites

Testing and use of these elements presented challenges unforeseen at the time the grant was written. Because interactive forums were included as a part of the site, users were required to register. In focus groups, educators told us they did not have time to engage students in the site during OST sessions or to register and explore the site on their own outside of OST sessions.

In an attempt to remove the registration barrier, we placed the videos and links on the opening page of the EA website, which did not require login. Even with this change, however, only 21% of field test sites reported accessing content. The primary reasons given by educators for not using the EA website resources included lack of time and problems with equipment—internet access was not available, computers did not work, and so on. Educators' comments on this issue included the following:

- "I did not have any extra time to [access the site]."
- "No internet access."
- "I would have if I had access to an overhead projector (computer screen is just not large enough)."
- Do not have internet connection in room we used for the adventures. Limited time also made it difficult to use computer lab and complete activity.

A follow-up survey sent to educators who downloaded the *Bubble Bonanza* unit asked several questions on what types of online resources and content would be valuable to support using Engineering Adventures. With respect to resources, the survey responses indicated that an E-newsletter, Facebook page, or postings on an OST listserv might be valuable ways to support EA educators. With respect to content, educators expressed interest in learning more about STEM education, asked for tips on how to teach EA units, asked for a help system where they could get answers to questions about teaching EA, and said they would like to know when new EA units became available. To address these questions, the Engineering Adventures team is creating an E-newsletter for educators. The quarterly newsletter will launch in May 2013.

Engineering is Elementary

Developed by the Museum of Science, Boston

Evidence of Demand for EA

Interest in the use of science, technology, engineering, and mathematics (STEM) programming in OST settings is growing. OST stakeholder organizations including the National Afterschool Association, the Afterschool Alliance, and the Coalition for Science Afterschool have publicly expressed a need for quality STEM activities that can be incorporated into OST programming. The National Afterschool Association website underscores this idea, stating: "Considering how science impacts our nation's strategic interests and security, we encourage our members and stakeholders to join forces with school personnel to increase the capacity of afterschool professionals to deliver instruction and engage learners in high quality STEM activities."[1]

Our experiences suggest that afterschool professionals are indeed working to include high quality STEM activities in their programs. The EA team has seen a steady and significant increase in demand for EA units since the program began in 2010. In the fall of 2011, 70 programs applied to field test EA units. The following year, the EA field test application was posted for just two weeks, during the 2012 holiday season—and even so, we had more than 320 programs apply for the 25 available spots. Figure 6 below shows the growth of field applicants over the past year and a half.

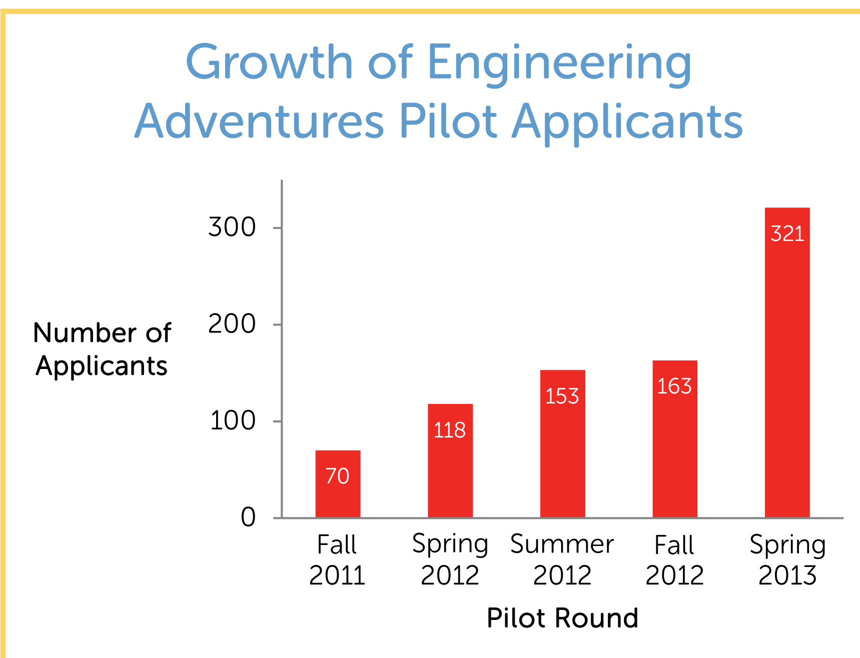


Figure 6. Growth of EA Pilot Applicants

The OST sites we have worked with vary greatly by program type and geographic location. EA units have been field tested in 31 states plus the District of Columbia (Figure 7 shows field testing locations).Over the course of the grant we have worked with 412 field test sites ranging from afterschool programs located within schools to

1 National Afterschool Association. STEM—The Year of Science. Retrieved January 3, 2013, from http://www.naaweb.org/default.asp?contentID=643

Boys and Girls Clubs, YMCA and YWCA programs, Salvation Army sites, 21st Century funded programs, and many more.

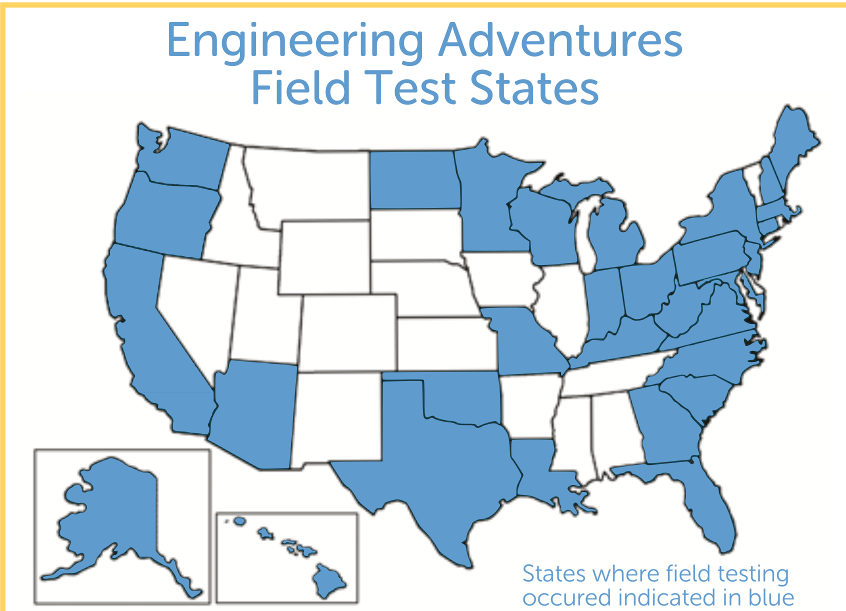


Figure 7. Engineering Adventures Field Test States

Further evidence of interest in engineering activities for OST can be found in the number of times EA units have been downloaded since they were released to the public. The *Hop to It* unit has been publicly available for almost five months and has been downloaded more than 300 times. The *Bubble Bonanza* unit has been publicly available for almost seven months and has been downloaded 930 times.

To learn more about who is using these EA units, the team sent an online survey to everyone who downloaded the *Bubble Bonanza* unit. The survey asked users to evaluate the quality of the unit quality, its usability, what they believed their children gained from participating in the unit, and whether they were interested in implementing other similar units in the future.

A total of 118 educators completed the survey. Of those educators who implemented the *Bubble Bonanza* unit at least once, most indicated the unit was easy to use, with 95 % rating ease of use as a 5, 6, or7 on a 7 point scale (1 = "not at all easy," 7 ="very easy"). Survey participants also rated the overall quality of the unit as high, with 100% of survey respondents rating the unit a 5, 6, or 7 (1 = "very low quality," 7 = "very high quality"). Nearly 100% percent of respondents indicated they were likely to implement the *Bubble Bonanza* unit again, and a full 100% of respondents indicated an interest in implementing other Engineering Adventures units.

In reviewing these positive results, it's worthwhile to note that, in contrast to the educators who helped to field test *Bubble Bonanza*—who were sent prepared materials kits to help facilitate the activities and offered email and phone support from EA curriculum developers--the educators responded to the survey had received none of these supports.

Figure 8 summarizes survey results related to participant learning and confidence. The results of this survey, showing that educators believed children's engineering skills and attitudes were positively impacted by participation in this unit, are consistent with the positive impacts found during EA field testing. This is especially noteworthy given that survey respondents did not receive the professional development supports educators received during the field tests.

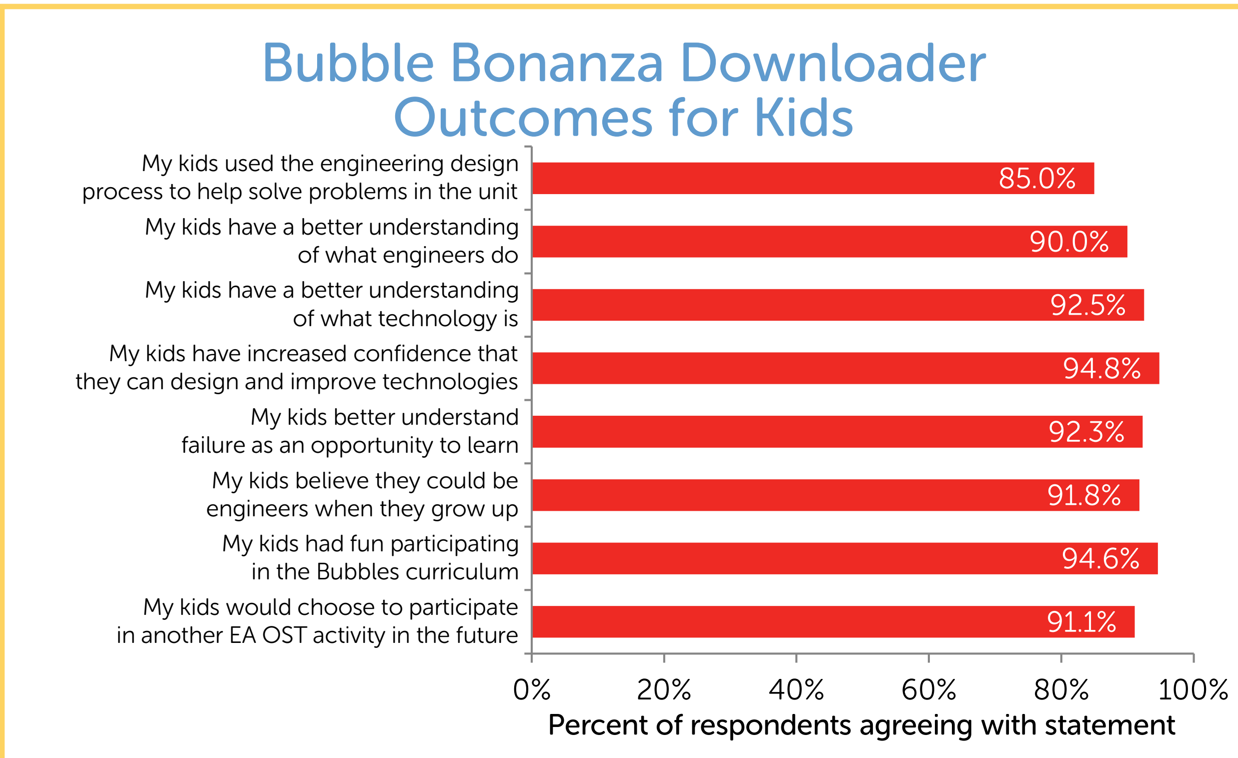


Figure 8. *Bubble Bonanza* Downloader Outcomes for Kids

We plan to send a similar survey this spring to educators who have downloaded EA's *Hop to It* unit. EA developers are particularly interested to see if positive content and attitude changes hold across units, as this will further support the notion that the critical components the EA program has identified for OST are indeed crucial for creating positive effects, no matter the science and engineering content highlighted in the unit.

Conclusion

This grant supported the development and testing of three new Engineering Adventures units, testing of two existing units, evaluation and revision of all five units, and creation and testing of website supports.

Through the process of testing and revising five EA units, the team has been able to identify several key ideas that have guided the development of later units:

- All activities within the unit must clearly and directly inform kids' work in the final challenge.
- Lessons must be structured to quickly allow children to engage in a hands-on way with materials.
- The steps of the engineering design process must be made explicit throughout all lessons.
- Activities should be sequenced, encourage active, focused involvement, and have explicit goals and learning objectives.

Given the positive feedback from both educators and children participating in Engineering Adventures, the team is thinking carefully about ways to ensure sustainability for Engineering Adventures moving forward. Evidence from the field indicating that OST educators and administrators would like to see continued creation and support of engineering content for their programs is outlined below. We also discuss some early sustainability initiatives tested by the team.

Sustainability Supports

The EA team has heard from OST educators and the Massachusetts Afterschool Partnership that there is a need for engineering professional development. To meet this demand, the team has begun to offer workshops on implementing engineering activities in OST. The workshops are designed to introduce OST educators to foundational hands-on pedagogical strategies and engineering habits of mind. While select Engineering Adventures activities may be highlighted, the workshops have the overall goal of illustrating broader concepts, for example, the idea that failure is expected in engineering and provides opportunities to improve, and the Engineering Design Process is a tool that can be used to help solve many different types of problems.

To date the team has conducted four workshops for a total of 60 participants. At the conclusion of the workshops participants are asked to fill out a brief evaluation.

A sampling of comments from the evaluation includes the following:

- "[The workshop] shed a light on some of the hidden aspects of teaching this curriculum, for example, how to respond to ideas that weren't as successful, how to draw meaning from "Imagine," "Plan," "Ask"!
- " . . . gives time to work out the bugs and flaws and prepares you to actually do a specific activity with students and adjust the difficulty for different groups."
- "We were engaged and time went by fast, one of the best workshops ever!"
- "I thought the hands-on activities that we did were very helpful. It was fun being the student and then switching back to teacher mode."

Participants rated the quality of the workshop as an average of 6.5 (1 =" poor" and 7 = "excellent").

As the EA team develops a plan for offering more professional development workshops, EA will begin to market the program in more strategic ways. We have been encouraged to see a steady increase in field test applications, especially given that the EA team has done very little marketing of the program. To date, word has spread primarily through OST educators and others in the field.

The EA team will also be presenting at several OST conferences including the annual meetings of the National Afterschool Association and Beyond School Hours. Through conferences and other media, the EA team hopes to share the development and evaluation findings outlined in this report. Just as the EA units are available to the public, our hope is that the criteria and design goals found through evaluation to benefit children engaging in engineering activities can also be made publicly available to benefit the broadest audience possible.

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