i2 and Engineering Everywhere Curriculum Development Grant

Annual Report

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Funded by i2 Camp
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“Engineering Everywhere definitely fosters cooperative team learning and team thinking; the curriculum was also relevant.”

—Educator, South Brooklyn Youth Consortium, NY

Project

Summary and Goals

The i2 and Engineering Everywhere Curriculum Development grant awarded to Engineering is Elementary (EiE) by i2 Camp funds the development of two related engineering curriculum initiatives for middle school-aged children in out-of-school time (OST) settings: week-long engineering courses for i2 Camp and shorter, derivative units for a publicly downloadable curriculum series titled Engineering Everywhere (EE).

The goals of the i2 and Engineering Everywhere Curriculum Development project include the following:

• Draft, pilot test, and revise 10 week-long i2 Camp courses.
• Draft, pilot test, and revise 10 derivative EE units.
• Conduct formative evaluation of EE units.
• Assist in formative evaluation efforts (including observations) related to the courses being developed for i2 Camp.

Because separate external evaluations were conducted on the i2 Camp courses, this report will focus primarily on the development, evaluation, and revisions of the EE units funded by the grant.

Program development

EE units are written for middle school-aged children participating in a wide variety of OST programs all over the country. The curriculum is specifically designed to present children with real-world engineering challenges and promote creative problem-solving.
Before beginning to create i2 and EE units, the team spent time discussing and identifying foundational concepts deemed essential for introducing middle school-aged children to engineering in an out-of-school time environment. This pre-unit development included the creation of an eight-step middle school engineering design process (Figure 1) that expanded upon EiE’s previously developed and rigorously tested five-step engineering design process for elementary school-aged children. The middle school version includes an “identify” step that guides children to define the problem in their own words, a “test” step that encourages multiple trials, and a “communicate” step in which children will share their design and their use of the engineering design process. These slight changes from the elementary school process give older children more autonomy to take ownership of the problem, value and apply data, and share their knowledge. All of these skills are developmentally appropriate for middle school.

While i2 units can develop concepts and scaffold learning over the course of several days, EE units must offer learning experiences in more discrete blocks. EE activities are often implemented one time per week, which limits the number of activities that can reasonably be included in a unit (normally an 8-week session would be the maximum). In OST programs it is common for children to attend from different schools or regions, and thus often contribute a wide variety of prior experiences and background knowledge. Guiding children to share their prior knowledge before jumping into an activity is pedagogically important as it creates peer-to-peer teaching and learning opportunities. Further, given the shorter blocks of time available for facilitating EE activities, guiding children to share
their knowledge can help to fill in some science and/or background knowledge gaps, building a common foundation for all children in the program.

An important difference between EE units and previous OST units we’ve drafted for younger children (grades 3-5), is an emphasis on encouraging children to be in control of their own learning and experimentation. Children in grades 3-5 usually need structured guidance (in the form of a research question or a set list of criteria and constraints) in order to begin an activity. In EE activities, we have given children a greater degree of latitude, empowering them to define the criteria and constraints for some of their challenges. This empowerment of children to have a hand in shaping their engineering challenge has been quite successful and the team intends to push this idea further as we revise existing units and create new units.

**Progress To-Date**

At the time of this report, the team has completed initial development of 6 EE units. Previous experience in the OST environment has taught the team that testing units in both afterschool programs and camp programs is critical. Several units have gone through testing in both environments, were revised after each pilot test season, and are nearly ready to be made available for public download before the end of the calendar year. Other units are just entering their first round of testing.

The sections below include descriptions of the activities included in each EE unit, a chart indicating which steps in the development process have been completed or are scheduled, and a summary of the changes made during revisions for each unit.
Put a Lid on It: Engineering Safety Helmets

Put a Lid on It is the EE version of the Crash Test Engineering course created for i2 Camp. The current draft of Put a Lid on It contains 7 activities:

- Prep Activity 1: Humpty Dumpty: Children are introduced to engineering and the Engineering Design Process as they work in teams to engineer a wall that will support Humpty Dumpty.
- Prep Activity 2: What is Technology?: Children play a Technology Jeopardy game that guides them to think about the breadth of technology.
- Activity 1: Pasta Package: Children explore ways to protect fragile pasta from breaking upon drop impact.
- Activity 2: Brains: Children learn about the lobes of the brain and the functions they control, then think about helmets designed for different activities.
- Activity 3: Create Your Helmet: Engineering teams Plan, Create, and Test their first helmet designs.
- Activity 4: Improve Your Helmet: Teams improve their designs to better meet the criteria.
- Activity 5: Engineering Showcase: Teams communicate their work to each other and to visitors.

Pilot Test Schedule

<table>
<thead>
<tr>
<th>Unit Drafted</th>
<th>Afterschool Test</th>
<th>Revision</th>
<th>Summer Camp Test</th>
<th>Revision</th>
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<tbody>
<tr>
<td>✓ Fall 2013</td>
<td>Winter 2013</td>
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Feedback and revisions: Similar to the i2 Camp version of this unit, there were lessons in the first draft that educators felt could be made more challenging to appeal to the middle school audience. Middle schoolers tend to have background experience with the types of materials made available to them in the unit, and thus do not need a full activity devoted to exploration of properties of materials. The revised unit being tested this fall eliminates the materials exploration activity and instead introduces brain anatomy, including the lobes of the brain and some of the functions controlled by each lobe. This introduction of science information is not only age-appropriate for the middle school audience, but should also help children better understand why it is so important to protect the brain with a well-engineered helmet.
Here Comes the Sun: Insulating Model Homes

Here Comes the Sun is the EE version of the Global Architectural Design course created for i2 Camp. Here Comes the Sun contains 8 activities:

- **Prep Activity 1:** What is Engineering?: Children engineer a tower and are introduced to the Engineering Design Process as a problem solving tool.
- **Prep Activity 2:** What is Technology?: Children explore the idea that technologies are any object or process that people create to help solve a problem and engineers design technologies.
- **Activity 1:** Children will be introduced to their primary challenge: engineering insulated model homes.
- **Activity 2:** Children will investigate several different types of insulation and will discuss the importance of controlling variables across groups.
- **Activity 3:** Children will learn about homes from around the world. They can use this information to inspire changes to the features of their own model homes.
- **Activity 4:** Groups begin creating their new model homes, using what they’ve learned about insulation to design a model with a stable interior temperature.
- **Activity 5:** Groups have time to make final improvements to their design, and also get introduced to a twist: their final test will be inside a refrigerator.
- **Activity 6:** Groups will participate in an Engineering Showcase to share what they have learned with others.

**Pilot Test Schedule**

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<td>Nov 2014</td>
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Feedback and Revisions: The first draft of this unit included several activities focusing on the effect specific variables had on the temperature of the models (adding windows and doors, for example). With middle school-aged children’s increased ability to balance and explore the impact of variables on their own, the activities that focused on breaking out each variable became repetitive. The revised version incorporated an activity popular in i2 Camp, an introduction to homes and insulation from around the world, provides participants with new knowledge and inspiration that makes the activity itself and the design challenge more exciting.

“After my kids completed this project they were even going over and beyond, asking if they could insure their [model homes] in case of hurricane, tornadoes, floods, fires, etc.”

**-Educator, Boys and Girls Club of Edinburgh, TX**
Don’t Runoff: Engineering an Urban Landscape

Don’t Runoff is the EE version of the i2 Redesigning Urban Landscapes course. It contains 7 activities:

- Prep Activity 1: What is Engineering: Children engineer a tower and are introduced to the Engineering Design Process as a problem solving tool.
- Prep Activity 2: Technologies at Work: Children explore the idea that they, as engineers, can design and improve technology and are introduced to their main design challenge.
- Activity 1: Green Possibilities: Children are introduced to green roofs and create their own to investigate the properties of natural materials.
- Activity 2: Passing Through: Children investigate permeable pavement technology by engineering pavement that will meet certain criteria.
- Activity 3: Creating an Urban Landscape: Engineering teams plan, create, and test a solution to their environmental engineering challenge.
- Activity 4: Improving an Urban Landscape: Teams improve their designs to better meet the criteria.
- Activity 5: Engineering Showcase: Children communicate their work to each other and to visitors.

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Feedback and Revision: While there is an inherent motivating factor to engineering challenges having to do with the environment, it can be somewhat abstract. Many children are not familiar with watersheds or the concept of storm runoff, but generally understand the need to keep our rivers and oceans clean. In order to build motivation, we added an animal component to the design challenge—a rubber duck “inhabits” groups models and acts as a tangible reason to prevent pollutants from entering the river.

“We wanted students to have an environmental learning reference for superstorm Hurricane Sandy and this curriculum addressed the issues of preparation and mitigation.”

-Educator, South Brooklyn Youth Consortium, NY
Food for Thought: Engineering Ice Cream
Food for Thought is the EE version of the i2 Engineering Ice Cream course. It contains 8 activities:

• Prep Activity 1: What is Engineering? Children are introduced to engineering as they work in teams to engineer a tower to support a marshmallow.
• Prep Activity 2: Food Technologies: Children learn about technology and imagine a technology to help someone eat food while underwater.
• Activity 1: Process as Technology: Children engineer a process for making a tasty treat and learn that processes are engineered as well as objects.
• Activity 2: Ice Cream Ingredients: Children learn about their ice cream engineering challenge and investigate ice cream ingredients and processes.
• Activity 3: Ice Cream Appeal: Children investigate ways to alter the flavor, texture, and color of their ice cream.
• Activity 4: Package Your Ice Cream: Children engineer a package to protect their ice cream from heat and damage.
• Activity 5: Improve Your Ice Cream: Children engineer a package to protect their ice cream from heat and damage.
• Activity 6: Engineering Showcase: Children communicate their work with visitors.

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Feedback and Revision: The first draft of this unit contained 9 activities. Along with engineering their own ice cream with a focus on taste, texture, and color appeal, children were guided to explore edible packaging and possible machines used to make ice cream. Educators expressed that the activities that were less focused on creating ice cream felt tangential. Because they also tended to require substantial materials and background knowledge, the activities tended to be rushed or get cut off. The entire unit was streamlined to keep the focus squarely on the process of creating an appealing ice cream product. The new version of this unit will be tested this fall.
Go Fish: Engineering Prosthetic Tails

The i2 counterpart to this EE unit has not yet been tested. It contains 8 activities:

• **Prep Activity 1: What is Engineering?** children will work together to engineer a model life vest that can float an unopened can.

• **Prep Activity 2: What is Technology?** Children will learn that engineers often design new technologies (anything created by people to help solve problems) when faced with new problems. Children will play a Jeopardy-style game to understand technology.

• **Activity 1: Fishy Movement:** Children will make observations of fish movement by taking a virtual tour of an aquarium. Children will then build a model of a fish and consider the advantages and disadvantages of using models.

• **Activity 2: Going with the Flow:** Children will be introduced to their final challenge of the unit by watching a video of Winter, the dolphin with a prosthetic tail. Children will then begin Investigating by making observations of a robotic fish and explore which materials are effective in designing a prosthetic tail.

• **Activity 3: Creating a Prosthetic Tail:** Children will use what they have learned about prosthetic tails and the Engineering Design Process to engineer a prosthetic tail.

• **Activity 4: Improving a Prosthetic Tail:** Children will use the Improve step of the Engineering Design Process as they alter the prosthetic tails of their fish model to better meet the criteria.

• **Activity 5: Something’s Fishy:** Children will develop a unique fish with its own characteristics. They will also design the exhibit signs for their Showcase.

• **Activity 6: Engineering Showcase:** Children will share the prosthetic tails they engineered, as well as their fish and exhibits.

### Pilot Test Scheduled

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Notes for Pilot Testing: We expect that the challenge of creating a prosthetic tail for an injured fish will be inherently compelling for children. During observations and in educator feedback, we will focus primarily on whether children are appropriately engaged with the model fish they will make as part of the EE unit. The i2 version of this unit will guide children to create a more complex fish model than that used in the EE version. In i2, we plan to incorporate a servo motor to create the movement of the model fish. In the EE version the movement is created manually by children pulling their fish through the water. We will be watching closely to see if the manual EE model excites and engages children.
**It’s About Time: Engineering Game Timers**

The i2 counterpart to this EE unit has not yet been tested. It contains 8 activities:

- **Prep Activity 1: What is Engineering?** Children will engineer a tower to support a marshmallow and will be introduced to the Engineering Design Process as a problem solving tool.
- **Prep Activity 2: Technology Through Time:** Children will learn the definition of technology and match pairs of older and more modern technologies. They will also imagine ways to improve the modern version.
- **Activity 1: What Time is It?** Children will explore their perceptions of time and discuss the need for engineered timekeeping devices to accurately measure time.
- **Activity 2: We All Fall Down:** Children will engineer a timer by exploring the natural rhythms of falling dominoes.
- **Activity 3: Drip Drop, It’s a Clock:** Children will experiment with water timers and engineer a one minute timer. They will then use their timer to compete in a one minute challenge.
- **Activity 4: Relay Race Timers:** Children will begin designing a water timer for their final design challenge. Their water timer will be used for a four-part relay race and will need to measure four 30 second blocks of time.
- **Activity 5: Time’s Up:** Children will improve their relay race timers. They will also be challenged to add a display or signal to their timers.
- **Activity 6: Engineering Showcase:** Children will share the water timers they engineered and use them to compete in a relay race.

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Notes for Pilot Testing: The EE version of this unit focuses primarily on the use of water timers and ultimately guides children to create water timers. The i2 draft introduces many different kinds of timekeeping devices and allows children to choose the focus for their final design by drawing from all of the technologies they explored throughout the week. When observing this EE version, we will be watching closely to see whether children engage with the context for the design challenge and feel compelled and excited to create timekeeping devices.
Future Development Plans

As specified by the grant, four additional i2 and EE units will be created by October of 2014. The team is engaged in brainstorming possible topics for these units, including bioplastics and polymers, bioinspired textiles, water supply issues, and engineering systems to prevent the spread of pandemics.

The team has continued to think about different ways to present the context for the challenges presented in both EE and i2 units. Pulling from the Grand Challenges of engineering as identified by the National Academy of Engineers is our starting point for the subject of each unit. The grandiose, real-world nature of the problems identified are an excellent fit for the middle school age group. It is therefore important to convey the exact engineering challenge children will be asked to tackle in an equally compelling way. Throughout the late summer and fall of 2013, we have been working with a videographer to create context-setting videos for the first four i2 and EE units.

The videos will be short, approximately 7-10 minutes long, and will present each challenge using a macro/micro/macro structure. First the video narrator will talk about the problem on a global level—“Why is runoff a problem that affects many people? Why should I care?” Then the video will present dynamic interviews with experts in the topic presented in each unit. In the case of the Don’t Runoff unit, for example, the Director of the Charles River Watershed Association shares how runoff has affected the Charles River and some of the solutions engineered to solve the problems.

Finally, the narrator will present a summary of the impetus for engineers to tackle this problem and will pose the challenge to the children in the camp or OST program, effectively setting them up to jump into the rest of the activities in the unit.

We believe that the video medium will appeal to middle-school aged children, especially given the news program-type treatment the videographer will be creating for the opening and closing sequences. We expect two of the videos (for Here Comes the Sun and Don’t Runoff) to be completed in November, the remaining two before the end of 2013.
Assessment and Analysis

Because the Engineering Everywhere and i2 curricular units are still in development, our assessment and analysis efforts have focused on formative evaluation. Data collected through formative evaluation are used to inform the development process by providing insights into the unit’s activities, the materials used, and the overall structure of the unit. These insights are made possible by the evaluation tools and methods that our team develops specifically to improve our understanding of how our units perform in the field. These tools are wide ranging and include surveys, interviews, focus groups, and student work samples. A detailed description of several of our assessment tools, along with their results, is provided below.

Educator Feedback Survey

The Engineering Everywhere team is very interested in how our curricular units are received by the educators who teach them. We realize that a high quality curriculum is not only fun and engaging for the students, but is also accessible and well organized for the educator. As our team began pilot testing both the EE and i2 units during the spring and summer of 2013, we asked educators to complete an Educator Feedback Survey. Both the EE and i2 versions of this instrument gather data from the educator’s perspective about the overall quality of the unit, the level of student engagement, and the age-appropriateness of the unit’s activities. This tool also gathers data from the educator about their willingness to teach the same unit again and their thoughts about how the unit could be improved.

In general, educators working with both EE and i2 curricula gave high marks across a variety of items on the Educator Feedback Survey. Several of the more compelling items are detailed below.

Overall Quality Score

Educators who taught EE units during the spring and summer of 2013 gave high Overall Quality Scores. Out of a possible 7 points, educators gave an average rating of 6.1. A breakdown of Overall Quality ratings across the four EE units that were tested can be seen in Figure 1.1. The Overall Quality Score is a helpful indicator of how our educators regard our curricular units. A low score on this indicator serves to alert our team to the possibility that significant alterations may be necessary. A high score, such as the ones we received from educators this spring and summer, provides a measure of confidence that the materials and activities we have developed are working well in the field.
Level of Engagement Score

EE educators also gave high marks on the Level of Youth Engagement Score. Out of a possible 7 points, educators gave an average rating of 5.9. A breakdown of Overall Engagement ratings across the four EE units that were tested during the spring and summer of 2013 can be seen in Figure 1.2. Responses to this item are useful because they give our team a sense of how the children are reacting to the curriculum. We design our activities with the hope that they will be appealing and engaging to a broad and diverse audience. From a high engagement score, we can infer that children are enjoying the activities. A lower engagement score may indicate that changes will need to be made in order to capture and maintain the interest of our audience.

Both the unit quality and level of engagement scores are lowest for the Don’t Runoff unit. While not alarmingly low, the curriculum team prefers to see ratings very
of 6 or above on the 7 point scale before we feel completely confident releasing a unit. Revisions prior to releasing the Don’t Runoff unit will focus on enhancing the messaging around why runoff is an issue and how environmental engineering solutions can help (we anticipate the video will help with this) and streamlining the materials and instructions for educators. After the unit is made available to the public we will send an electronic survey to educators who have downloaded the unit in order to continue tracking educator perceptions of unit quality and engagement, and continue making changes if necessary.

### Likelihood of Teaching Again

The EE version of the Educator Feedback Survey also asks a variety of open-ended questions. By gathering narrative responses, these items provide a helpful context through which we can better understand the quantitative data. For example, educators are asked, “What is the likelihood that you will choose to use this unit again?” The responses to this item provide data on how satisfied educators are with the unit, which helps us to contextualize any of the other comments that educators may make throughout the Survey. While generally positive, the comments can also help developers understand the types of revision that will benefit the unit. Examples of educator responses to this particular item are provided in Table 1.1.

<table>
<thead>
<tr>
<th>EE Unit</th>
<th>Question: What is the likelihood that you will choose to use this unit again?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put a Lid on It</td>
<td>With modifications in time and instruction, I would definitely choose to use this unit again.</td>
</tr>
<tr>
<td>Food for Thought</td>
<td>Very likely. The topic is very appealing to kids of all ages and it is rare to have this age group interested in such an educational program.</td>
</tr>
<tr>
<td>Here Comes the Sun</td>
<td>I am very likely to use this unit again. It was simple enough to teach and the kids learned a lot.</td>
</tr>
<tr>
<td>Don’t Run Off</td>
<td>We are already planning on using it during the summer and fall 2013 programs.</td>
</tr>
</tbody>
</table>

### i2 Camp – Educator Feedback Survey

A version of the above detailed Educator Feedback Survey was also used to collect data from educators teaching the i2 units during the summer of 2013. This survey was made available online so that educators across the three i2 Camp settings could easily access
and complete the form. Educators were asked to fill out the survey after each day of camp. While many of the items differed from the EE version, the purpose of the survey was the same. Two of the items are detailed below.

The i2 version of the Educator Feedback Survey asked educators to discuss which activities worked well on that day. Table 2.1 shows some of the responses across the four units.

<table>
<thead>
<tr>
<th>i2 Unit</th>
<th>Question: What activities worked well today?</th>
</tr>
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<tbody>
<tr>
<td>Crash Test Engineering</td>
<td>All the activities worked well today because they were very hands on and tied in well to the concepts addressed in class. The best activities of the day were the concussion goggles because the students actually got to feel what a concussion does to your vision as well as your motor skills.</td>
</tr>
<tr>
<td>Engineering Ice Cream</td>
<td>The spice mixture exercise went really well! Some great creations were made. I wish we had time to spend on the &quot;improving&quot; step. They were really into it.</td>
</tr>
<tr>
<td>Global Architectural Design</td>
<td>Warm up with the mammoth. Kids loved the idea. Created very interesting designs. I wonder if not providing cups as an option would allow for more creativity.</td>
</tr>
<tr>
<td>Redesigning Urban Landscapes</td>
<td>The filter system and starting to create the model system got the kids thinking about how our small projects impact the big one and our communities as a whole.</td>
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</tbody>
</table>

The i2 Educator Feedback Survey also asked educators to discuss which activities need improvement. Table 2.2 shows some of the responses across the four units.

<table>
<thead>
<tr>
<th>i2 Unit</th>
<th>Question: What activities need improvement?</th>
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<tbody>
<tr>
<td>Crash Test Engineering</td>
<td>I would have more quantitative data collection in the challenges so the students can incorporate math into the testing process.</td>
</tr>
<tr>
<td>Engineering Ice Cream</td>
<td>In adding additives to the mixture (xanthum gum, etc) and giving the kids many other variables through flavor extracts, the ice creams did not come out well. We suggest sticking to a few variables so that the kids can focus more on the differences between a few instead of throwing everything in (which they are inclined to do).</td>
</tr>
<tr>
<td>Global Architectural Design</td>
<td>While the houses needed to be built, I feel like getting more examples of how to build alternative shaped houses would have helped students grow their thinking.</td>
</tr>
<tr>
<td>Redesigning Urban Landscapes</td>
<td>The buildings for the green roof were extremely messy. The materials ended up on the floor and it took a while to clean.</td>
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</tbody>
</table>
As i2 educators provided these responses our team closely monitored the online survey to see how their feedback could be used to improve our units. The feedback from educators is constructive and is highly valued by our team because it represents an outside perspective and often contains fresh ideas.

**Educator and Youth Focus Groups**

The Educator Feedback Survey is a powerful tool, but it does not allow for educators to think collaboratively about the feedback that they provide. To give educators an opportunity to formulate their opinions and ideas as a group, our team facilitated educator focus groups. Focus groups with educators teaching the EE curriculum were conducted during the spring and summer of 2013. These sessions generally involve four or more educators and can last from 1-2 hours. Takeaways from these focused discussions are very valuable for the curriculum team and generally include ideas for how to better organize activities, suggestions for materials that could be added or removed, and anecdotes about challenges or successes that occurred during implementation.

In addition to educator focus groups, our team conducted two youth focus groups with the children involved in the i2 spring 2013 pilot at the Roxbury Latin School, in West Roxbury, MA. Children were encouraged to speak freely and to discuss with the group how they felt about the activities, the materials, the timing, and the overall structure of the i2 unit in which they participated. During this discussion, the educator was not present and the children provided honest and valuable feedback. From this feedback our team generated a list of key takeaways that continue to shape the way we organize and develop our i2 and EE units. Examples of some of these takeaways can be seen in Table 3.1.

| Table 3.1
<table>
<thead>
<tr>
<th>Key Takeaways from i2 Youth Focus Groups</th>
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<tr>
<td>Start each day with a design challenge—whether related to main camp challenge or not, this gets the kids brains working and gets them excited about the day.</td>
</tr>
<tr>
<td>Think about ways to build the excitement throughout the week. Doing an amazing fun activity on day one is great, but that sets an expectation for what the whole week will be like.</td>
</tr>
<tr>
<td>Lots of breaks! You need a break pretty much between each activity.</td>
</tr>
<tr>
<td>We need to focus any sort of presentations or report outs so that kids know what is expected of them and what they should be focusing on. Creating some parameters around these presentations is important.</td>
</tr>
</tbody>
</table>
Engineering Attitudes Survey

The data collection tools described above work in concert to provide our team with tangible insights into the performance of our curricular materials. These insights allow us to make edits and alterations that are data-driven. In addition to this emphasis on formative evaluation, our team is also interested in understanding how the middle school age group conceptualizes engineering, and whether these conceptions change after participation in our EE units. To this end, we have developed a thirty-question survey that is intended to capture children’s attitudes toward engineering. The Engineering Attitudes Survey presents statements related to engineering and asks children to rate their level of agreement with each statement on a Likert scale (1=Strongly Disagree, 5=Strong Agree). This survey was completed by children who participated in EE units during summer 2013 pilot testing. Our current version of this instrument is given to children after they have completed their EE unit. It asks them to rate their current level of agreement with each statement, but also asks them to reflect on how they would have rated that same item before participating in the EE unit. This allows our team to cautiously draw conclusions about how children’s attitudes toward engineering may change through participation in an EE unit.

Figure 2.1 shows the comparison of pre- and post-assessment attitudes across four of the more compelling items on the Engineering Attitudes Survey. These data clearly suggest that children believe they have changed their attitudes about engineering after participating in an EE unit.

![Figure 2.1](image-url)
Evaluation Conclusions

While formative evaluation is primarily used to make improvements to our curriculum, it also provides an opportunity to take stock in what we have accomplished. So far our data suggest that the EE and i2 units are being well received by both educators and children. Feedback from educators, whether obtained through surveys or focus groups, has been overwhelmingly positive. Similarly, children participating in EE are showing positive growth in their attitudes toward engineering, and children participating in i2 are responding favorably to the challenges and engineering opportunities provided by our units. As the development of these curricula progresses, our team will continue to use, and improve upon, the tools and methods described in this report to support the development process.
Demand for Engineering Everywhere

Interest in the EE curriculum, as evidenced primarily by applications to pilot the program and email inquiries, has been high. The team attributes this to several factors, including the national interest in high-quality STEM programming expressed by organizations such as the National Afterschool Association, the Afterschool Alliance, and the Coalition for Science Afterschool, the lack of middle school engineering curricula specifically written for an OST setting, and the national recognition of the EiE curriculum brand.

While the team was pilot testing the Engineering Adventures curriculum (aimed at grades 3-5 children in afterschool program) we received many inquiries about similar units for middle school aged children in OST. Thus, we anticipated Engineering Everywhere would receive a very positive response. This was confirmed by the number of pilot applications received during the last three rounds of testing. On average we received four times as many applications to pilot the units as there were pilot spots available. The graph below (Figure 3) shows the number of pilot applications received vs. the number of pilot spots available.

The OST sites we have worked with vary greatly by program type and geographic location. EE units have been field tested in 26 states plus the District of Columbia (Figure 4 shows pilot testing locations). To date we have worked with 80 test sites ranging from afterschool programs located within schools to Boys and Girls Clubs, YMCA and YWCA programs, Salvation Army sites, 21st Century funded programs, and many more. This geographic and
Programmatic diversity is important during the testing phase to confirm that the units will work in the widest variety of settings possible.

**Sustainability Supports**

While interest in pilot testing EE has been high, the team is acutely aware of the need to introduce the curriculum to the broadest audience possible. The team will submit EE focused conference session proposals to the National Afterschool Association and the Beyond School Hours annual conferences.

The team has developed and tested an OST educator professional development workshop for our Engineering Adventures program. The work done to create that workshop will inform a similar workshop for educators working with middle-school aged children. The first EE workshop will be held in the spring of 2014.
Conclusion

Throughout the past year, this grant supported the development and testing of six new Engineering Everywhere units, and evaluation and revision of four of these units.

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

• The real-world, impactful nature of the challenges should be presented to children in a compelling way.
• Children should be given time to share knowledge with peers.
• All activities in the unit should present relevant ideas and investigations to children, but should allow them to influence and guide their own learning.
• 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 activities.

Given the positive feedback from both educators and children participating in the first four Engineering Everywhere units, the team looks forward to the development of the remaining units and continued growth of the program.
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