implementation. Read about a summer enrichment experience. Immersive structure for students to engage in the curriculum and delve into their own development.

Summer Enrichment
Summer programs offer an appropriate environment for implementing the Design and Discovery curriculum. Full or half-day summer programs provide an intensive and immersive structure for students to engage in the curriculum and delve into their own project development. Read about a summer enrichment experience.

In-School
While the Design and Discovery curriculum is most suitable for an informal education setting, it can be implemented in formal education. A school with longer periods, such as a block schedule, provides the necessary structure for the hands-on activities and project development. Read about Design and Discovery in a school in Massachusetts.
Student Projects

Project Examples

Read about projects that students designed while participating in programs that used the Design and Discovery curriculum. See how students apply the same process that engineers use to develop new products and improve on existing ones.

Kellie

**Instant Ice Pack Dispenser**

Kellie, a Design and Discovery participant, saw a need for an instant ice pack dispenser and engineered her own solution.

When you suffer a sports injury and need an ice pack, you want relief right away. If you're the active type, chances are you don't want to be weighed down with an ice pack that's bulky and cumbersome.

Kellie, a high school freshman who participated in a Design and Discovery summer program, had those user needs in mind when she set out to design a dispenser that could be used to create ice packs of different sizes. "I started thinking about this when my mom had a bike accident and hurt her finger. She wanted an ice pack that would treat her injury, but wouldn't hinder her recreational activities. That got me thinking," Kellie says.

Her prototype has two tanks connected to valves. One tank holds a water and gelatin mixture. The other holds Epsom salts or magnesium sulfate. When mixed together, the ingredients from the two tanks have an endothermic reaction, cooling the solution to the freezing level. The valves lead into a bag that can be heat-sealed to create packs of varying sizes. Kellie explains how it works: "You turn on the valves. The material flows into the bag. Once you have enough material, you turn off the valve and heat-seal the bag, creating an instant ice pack that's just the size you need." She envisions her product being used in a hospital setting, physical therapy center, or a gym. "Eventually, it could be used for personal use, but I have a little ways to go," she says.

Kellie's design has gone through several revisions. She started with a design that had pockets to hold an ice pack, only to discover that a similar product had already been patented. Next she tested prototypes that resembled a tape dispenser and one that operated like a squirt bottle. Each posed functional challenges. Eventually, she arrived at the gravity-feed prototype that she entered in a regional science and engineering fair. She
plans to keep working on her project during a second-year Design and Discovery program. "I like engineering. I like taking stuff apart and putting it back together. It's fun."

Allyson
Portable Wheelchair Ramp
Allyson attended a Design and Discovery program and started working on a portable wheelchair ramp. She has continued refining her idea, designing a model that meets user needs in a new, effective way.

When Allyson attended a Design and Discovery summer program and learned that she would have a chance to invent her own new product, the eighth-grader decided she wanted to develop something useful. "I didn't want to do anything that's kind of silly. I wanted to do something helpful. I started thinking, what problems are out there? My house has stairs leading into it. How would someone in a wheelchair get into my house?"

Using a combination of mathematics and materials engineering processes, Allyson developed a model for a portable wheelchair ramp that expands to 10 feet long. Using a type of fold called a square spiral, her ramp folds down "really small, to 9 by 3 inches," she explains. "It's meant to be made of a lightweight metal so that someone in a wheelchair could carry it along. It unfolds easily to sit flat on the stairs. My design specs call for it to be light, strong, and collapsible."

When she started working on her design, Allyson went online to research standards set by the Americans with Disabilities Act. "I read that a ramp has to rise an inch and run 12 inches. We studied rise and run last year in math. When I read the standard that said it had to be 1 over 12, I understood right away that has to do with slope." She used a protractor on a set of stairs to help her visualize the appropriate slope and a computer program to generate a visual representation of the spiraling design.

Allyson has worked through a series of models to refine her design, using cardboard and foam core. She hit a challenge when she went looking for a hinge that would meet her design requirements. "I realized I need a one-way, flat-line hinge so the ramp could be folded up flat but would not collapse in on itself when weight is applied. I've looked in hardware stores everywhere and can't find what I need. I'm going to have to design one myself," she says, "even though I've never tackled anything like that before. It's an interesting challenge."

She has been emailing aviation engineers to try to get pieces of scrap metal she can use for analyzing the most appropriate material for her ramp prototype. "It needs to be strong and lightweight, but it also needs to be reasonably cheap or nobody could afford to buy it. Titanium is strong and light, but also pretty expensive. I'm thinking a titanium alloy will be the way to go."
Allyson's project won third place in the Middle School Engineering category of the Northwest Science Expo and received the Herbert Hoover Presidential Library Association Young Engineer Award.

Taylor
The Mix and Matcher: Functional Jewelry Storage
Before she attended a Design and Discovery program, Taylor had no idea what engineers do. The curriculum taught her to apply engineering concepts to design a better way to store her favorite necklaces.

An artistic eighth-grader named Taylor remembers something the facilitators said during the first session of a Design and Discovery summer program. "They told us to go home and find problems in everyday life." Right on the dresser in her bedroom, she found a problem that needed fixing.

Taylor describes the story behind her design project, called the Mix and Matcher: "I have an old-fashioned jewelry box. Half of it is for necklaces and half for anything else you need to put into it. The problem is, my necklaces would tangle. When I'd try to untangle them, they would break." She did some user surveys and discovered she wasn't the only one annoyed by this problem. Her mother hangs necklaces from drawer knobs to keep them separate. Another woman told Taylor she lays necklaces flat on a tabletop to keep them from tangling. "No one uses jewelry boxes for storing necklaces, because they don't work well. It seems like designers have been more interested in appearance than function," Taylor concludes.

In designing the Mix and Matcher, Taylor had certain ideas in mind: "I decided to focus on the specific problem of storing necklaces so they wouldn't tangle. I wanted the user to be able to browse freely, and that meant including a motor." She did a patent search and was surprised to learn how many people had already invented jewelry-storage devices. "Everybody comes up with five different ways of solving the same problem. The challenge is figuring out the best solution," she says. When the patent search didn't turn up a solution similar to hers, she moved forward with developing a model and prototype.

The Mix and Matcher uses small hooks to hang necklaces individually on a circular display disk. A motor rotates the display, much like a clothing rack at a dry cleaners. Taylor worked with a mentor who had a background in electrical engineering. "I didn't know there were so many kinds of motors. One type turns continuously, like a windshield wiper. Another starts and stops when you push a button. That's what I wanted. It's called a stepper motor," Taylor explains. "It allows an object to move at a certain angle and rotate."

They ordered the stepper motor from a mail-order supplier, then had to work through some
wiring challenges to make it work with the knife switches on her prototype. During the Design and Discovery program, Taylor learned how circuits and switches work. "If we hadn't done that, I would never have thought about motorizing a jewelry box." Taylor also used her design notebook to make extensive sketches of the invention she had in mind. "Writing everything down was really helpful. I kept all my ideas in one place." One of the most satisfying moments of the whole process? "When we tested the motor and it worked!"

Now that she has built a functional prototype, Taylor has more ideas about refining the appearance of her Mix and Matcher. "I want it to be inside a box with a glass door so you can see what's going on inside. You'll see the necklaces moving, but you won't see the mechanics."

Taylor's project was awarded third place in the Middle School Engineering category of the Northwest Science Exp and received the IEEE Oregon Outstanding Computer Engineering Project Award.

Caitlin Sliding Chicken Door
Raising chickens as a hobby gave Design and Discovery student, Caitlin, the idea for a safe and secure chicken coop door.

Caitlin learned from experience about the risks of raising chickens in a backyard coop. "We kept our first chicks outside in a fenced-in area, where they could get some fresh air. A raccoon pulled them through the fence," she said. When her family got another batch of chicks, Caitlin was determined to design a coop that would be safer. "I wanted the coop to have an open area so the chicks could run around and get fresh air, with a door that would be easy to move up and down. We couldn't have the door crashing down on a little chick. It had to keep the chickens in and the predators out."

Attending a Design and Discovery program helped Caitlin take a thoughtful approach to solving her design challenge. "I used to think you could just get an idea for something and jump to conclusions. The program opened my eyes to the whole process—all the steps I was missing before."

As she set out to design her sliding coop door, Caitlin considered and discarded a number of ideas. Her design notebook is full of sketches and notes she made while brainstorming. She describes how her ideas shifted: "At first, I thought about designing remote-control doors that would operate from the sides like elevator doors. I realized that could crush a chick. Then I thought of something like a garage door that would move up and down on a track. I wanted it to be remote controlled until I realized I had no experience working with remote controls. My current design has a door that moves up and down using pulleys and weights.
This one works pretty well."

She made design modifications to suit user needs and went through a series of cardboard mock-ups before she made her working prototype out of plywood. "Chickens peck at things, so I decided I should add a covering for the pulleys. Then I thought, how would I keep the door down and the weights up? I designed a weight lock so it stays in the up position. You slide the door up and secure the weight locks. To close it, you just push down and put weights in. It's very easy to operate."

**Andrea and Andrea**

**FreshH20**

Guinea pigs and other small mammals make great pets, but they do require routine care, including fresh drinking water. That can pose a logistical challenge for a family going away for the weekend or on a short vacation. A young guinea pig owner named Andrea set out to build a better water dispenser.

Andrea teamed up with another middle school girl, also named Andrea, as part of a summer Design and Discovery program. The girls settled on designing a better water bottle for a guinea pig after brainstorming ideas for different household products. The girls' first prototype was made out of plastic cups and empty film canisters. They envisioned a reservoir to hold a supply of fresh water, "but we didn't think about how the old water would drain out," they explained. Their next design incorporated a flushing system for draining the water, but the girls ran into a problem when they hooked it up to the sink. When the valve closed, the water kept running and came out the top.

The trial-and-error process helped them come up with ideas for more improvements. Once they had settled on a final prototype design, they headed out to look for materials. They describe their steps: "First we tried a store that sold yard irrigation systems, but those were too big to use in the house. Then we went to a local hardware store, and we found all the stuff we needed there. They had some timers which were pretty much perfect for our use."

At the Northwest Science Expo, affiliated with the Intel International Science and Engineering Fair (Intel ISEF), judges awarded the girls third place in Middle School Engineering category.
Samantha
The Playstar
Sixth-grader Samantha noticed that her dog became easily bored with toys and wouldn't play with any one toy for very long. This observation prompted her to explore the field of product development as she brainstormed a new solution to this problem.

As part of an in-school Design and Discovery program, Samantha learned how to look at everyday situations in a different way. With a creative mind and an eye on frugality, she came up with the Playstar, an all-in-one dog toy. After observing the variety of toys available to dogs, Samantha's exposure to the SCAMPER brainstorming technique led her to a design, which combines the many different elements of dog toys into one toy. With the creation of this combination toy, Samantha hopes dogs will become bored less easily. This toy offers something for every dog—something to chew on, jiggle, throw, squeeze, and squeak.

Samantha kept the users—all dogs—in mind during the development of her toy. She adjusted her design during the modeling phase, making different sized models, so the toy would fit the needs of all breeds of dogs. Samantha used her own dog during her prototype testing (due to science fair regulations, she was not allowed to test it on other dogs). The results from her testing were good—she saw that her dog played with this toy much longer than its other toys. Samantha tested her new toy numerous times to confirm her results and she made the same observation.

This novel idea won Honorable Mention in the Massachusetts Middle School State Science Fair, and Samantha is even considering applying for a patent.

Joey
The Flip Flop Folder
Getting and staying organized is never easy. But, now with the invention of one Design and Discovery student, it just got easier.

Joey's idea blossomed when he used the SCAMPER brainstorming technique on a notebook. He knew that his current three-ring binder didn't offer everything that he and many others needed. So, through SCAMPER, he substituted and combined many new features to create a much improved folder. Joey's requirements included that the new folder be the same size as other folders (8½ x 11) and not be much bulkier. He experimented with different materials that would be durable. The Flip Flop Folder includes many pockets and can hold different things, from note-cards to computer discs.

To conduct user testing, Joey created three folders and gave one to a nurse, an office manager, and a business person to use for one week on their jobs. After the week, they provided Joey feedback. He made improvements based on their feedback, including adding...
Velcro* to keep the computer disc from falling out, and adding a pencil holder.

Joey's project made it to the Massachusetts Regional Science Fair and the Massachusetts Middle School State Science Science Fair.

**Alex**

**Snoopy's Stash**

Alex's pet beagle has a tendency to overeat like most beagles, and Alex is always putting his dog on a diet. So, Alex set out to come up with a dog feeder that would dispense the proper amount of food. Snoopy's Stash helps people feed their pets faster and easier with its spout for water and chute for food.

His solution to the overeating problems involved creating a feeding device with a door that goes up and the pellets dropping through a hole when the door goes up. While Alex researched his solution, he talked to a lot of breeders about how much beagles should eat. Through his inquiries, Alex determined the appropriate amount of food that should be released.

By testing his prototype multiple times, Alex determined how much food would drop through the hole when the door goes up. Using a switch and pulley, he built a chute that had the proper tilt so that the correct amount of pellets came through each time.

Alex's project made it to the Massachusetts Regional Science Fair and the Massachusetts Middle School State Science Fair. As for the future of Snoopy's Stash, Alex plans to continue work on it and add a timing mechanism so that the dog can eat when no one is home.

**Gerardo**

**The Jel e brush**

Geraldo had a hard time coming up with an idea for his *Design and Discovery* project, until his teacher asked him about his daily habits. She noticed that he had gotten his hair cut and asked him how he kept his hair so neat. Gerardo explained his process of brushing his hair, adding gel to his hair, and then brushing again. Then it dawned on him that there must be a better solution to this.

With a push of a button, gel comes out of the Jel e brush, and can then be brushed through one's hair. At a luncheon with professional engineers, Gerardo demonstrated his design on one of the engineers. The engineer was so impressed that he has encouraged Gerardo to file for a
patent. This engineer is now his mentor and meets with Gerardo regularly to help him further develop his project. Gerardo's project made it to the Massachusetts Regional Science Fair.

Gerardo may not have aspired to go to college before this project, but now realizes that if he wants to be an inventor, he is going to have to work hard and continue his education.
Summer Enrichment
Implementation Examples

"This program is like magic for kids who are on the fence. What happens is that they come in mildly interested, ambivalent, and they totally catch fire! They have a light-bulb experience about design and engineering."

Ruthe Farmer
Program Organizer

Design and Discovery is a free curriculum that has been implemented by many Girl Scout troops all over the United States. In Portland, Oregon, the Columbia River Council has held Design and Discovery as a summer program. This is just one example of how the Design and Discovery curriculum has been implemented in an informal setting.

Program History
In 2001, Ruthe Farmer was hired by the Girl Scouts - Columbia River Council, in Portland, Oregon. She heard that the council was going to hire an outside consultant to coordinate a grant to implement a new engineering program for the Girl Scouts, and stepped up to oversee the program herself. Her marketing skills and experience working for an automation machinery manufacturer would serve her well.

The Girl Scouts – Columbia River Council has successfully run Design and Discovery summer programs and is planning to continue expanding the program. The success of these programs has depended on creativity, energy, and passion for Design and Discovery. When the program started, Farmer received grants, developed partnerships, hired talented facilitators, and provided an opportunity for hundreds of girls to engage in a design and engineering experience that may influence their interest in science and ultimately their future career path.

Many of the 40 Girl Scout councils in the United States have sponsored Design and Discovery summer day camps, residential camps, weekend programs, and after-school programs. Each setting is appropriate for implementing Design and Discovery.
Goals
When Farmer's Girl Scout summer program started, the goal was to increase the number of girls participating in science fairs in the engineering, math, and computer science categories since these categories are traditionally underrepresented by girls. While this goal has been met, with many Design and Discovery students participating and winning in science fairs, excelling at competitions has become a secondary priority.

Based on girls' responses to the program, the goals are now to expose girls to engineering in a positive way that they can relate to, through the design window; to have girls interact with adult role models who are engineers and designers; and to spark girls' interest in taking gatekeeper math and science courses in high school so they will be equipped for engineering courses in college.

Program Structure
In this summer day camp model, Design and Discovery is offered as a two-week full-day program for about 20 middle school-age girls. Each day, one or two sessions are covered, with time for lunch, recreation, and field trips. In the two weeks, students go through the first 13 sessions, culminating with each student developing a model. A Solutions Showcase is held at the end of the two weeks for students to share their models and get feedback from parents and community members.

The program continues throughout the school year with interested girls gathering once a month, on a Saturday or after school, to continue the curriculum and ultimately develop prototypes. In each of these "alumni" sessions, students continue working on their projects and meet with their assigned mentors who assist them with their project development. During this time, participants also plan an engineering event, Girls Engineering Day, for their peers and to interest younger girls in engineering. On this day, they run engineering activities and showcase their projects. Finally, the girls can choose to submit their projects to the Northwest Science Expo, the regional fair affiliated with Intel International Science and Engineering Fair (Intel ISEF). Many Columbia River Girl Scouts who have participated in Design and Discovery have taken home medals and special awards and received much public recognition from this fair.

The Facility
When planning the summer camps, Farmer looked for appropriate facilities to house them. Criteria are used when selecting a facility. The site needs to be accessible to participants,
meaning that it is a facility that already is used for youth programs or that is reachable by public transportation. The site needs to be in a location where the target populations live. Ideally, the site will have an existing infrastructure, for example, a lunch program, recreational facilities, a game room, and a computer room. Most importantly, however, Farmer emphasizes that the facilitators have complete control over the room—they need to be able to lock up supplies and have a place to leave projects if necessary.

A variety of settings have met these requirements. Design and Discovery has been held at a local high-tech corporation, Police Activities League, Intel Computer Clubhouse, a youth center operated by a local nonprofit organization called Self-Enhancement Incorporated, a summer school for children from migrant families, and in partnership with university schools of engineering. A partnership with Washington State University’s new engineering and science institute led to a summer program where Design and Discovery students had access to all of the engineering labs on site. After the summer program, professors and graduate students facilitated workshops using advanced engineering equipment to help students with their design projects.

"The important thing when choosing a site," explains Farmer, "is that the organization have buy-in and truly understands the nature of your program. If the host site's youth members are participating, it should be made clear that this is not a drop-in program, that participants are expected to stay the whole day and complete the camp. It's best if the room is in a separate area so it is removed from other activities."

**Participant Selection**

Although the program is run by Girl Scouts USA, the participants do not have to be Girls Scouts to enroll. (Through participation, they become Girl Scouts and fulfill the requirements of the Girl Scouts Inventions and Inquiries Interest Project.) Girls are recruited through a Girl Scout mailing, newsletter, local presentations, and word of mouth. Interested girls complete an application form which includes answering essay questions about their interests in school and interest in participating in Design and Discovery. When students have come through one of the host site programs, the host site should emphasize the seriousness of the Design and Discovery program. Students who are selected should perceive their selection as an honor. Farmer also believes each of the participants should pay, even those who are on scholarships. Farmer says, "If kids don't pay anything, it is not valued." For Farmer's program, participants pay $150. She believes that it is possible to charge up to $250, but this would make the program inaccessible to some participants from lower-income families. The fee helps cover facilitator, supply, and field trip costs.
Facilitators
Each program has two facilitators per 20 students and a support person who is in charge of the materials (although this position is not essential, Farmer notes). Girl Scouts – Columbia River Council runs several programs throughout the summer. They try to spread them out so that the same facilitators can work in all of the programs. The monthly alumni session is a combination of participants from all of the programs and is run by one facilitator. Ideal facilitators have had experience working with youth and ideally have a background in engineering or sciences. Facilitators have been recruited from local universities and professional organizations.

Mentors
Because Design and Discovery facilitators are not meant to be experts on every topic in the curriculum, mentors play an important role. In this program model, there are two types of mentors: special guest engineers and project mentors. Special guest engineers help with specific engineering activities in the curriculum. They are recruited by emails to major corporations and to the Society of Women Engineers (www.swe.org*). Project Mentors are recruited during the program on an ongoing basis to mentor students one-on-one with their specific projects. Mentors and students meet during the program and often they are both so engaged that they meet on their own time.

Field trips
"Getting off site and out into the community is integral to the success of our Design and Discovery program," explains Farmer. Each program includes about three field trips. Field trips range from a quick trip to a local hardware store or the light rail station to a working session with and tour of a design firm. "Field trips are a great way to engage corporations in the community, and students love to see where professional people work and what they do," adds Farmer. Farmer likes students to see engineers and designers in action. Ideally, the host organization will be involved in planning the field trip and will structure activities that are meaningful to the students. "When selecting sites, it's important that they be visually interesting, and it's nice if they serve lunch, too," states Farmer.

Successes
"I like to say that our Design and Discovery program is not for students who are already fast-tracking to high achievement in math and science. This program is like magic for kids who are on the fence. What happens is that they come in mildly interested, ambivalent, and they totally catch fire! They have a light-bulb experience about design and engineering," Farmer says.

"Girls become invested in their projects," Farmer says, "because the projects are based on
their experiences and are derived from their lives, as opposed to challenges issued by adults." She also believes that having the participants do what engineers do gives them a real-life experience of what it would be like to be an engineer. She likes that the curriculum approaches engineering from a design perspective. For some girls, this makes engineering more appealing—it demasculinizes the world of engineering. "It's about everyday objects and problem solving, not just cars and bridges," she states.

Farmer is enthusiastic to share stories about how participation in the Girl Scout Design and Discovery summer program has changed participants' lives. She talks about one student who is a non-native English speaker who blossomed as a result of the program. "She went from the shyest person to the most precocious," explains Farmer. As a result of Design and Discovery and her newfound interest in engineering, this student earned a scholarship to attend a three-week summer engineering program.

Many students have won awards at the Northwest Science Expo and have continued entering projects in the high school division of the fair. Former Design and Discovery students have acted as program aids the following year, and now have a special opportunity to participate in a second Design and Discovery experience, designed for program alumni.

**Challenges**

Students need to be interested and self-motivated once they begin the program. This is not something you can force. Explains Farmer, "You need to accept that not every student is going to be an engineer." Another challenge is helping students to narrow down a project idea so that it's realistic. "It's important to help them hone in on what is an appropriate project," says Farmer.

For more information:

www.girlscoutscrc.org/program*
www.engineergirls.org/*
In-School

Implementation Examples

"I didn’t know anything about engineering or design, and it opened my eyes up to a whole different way of presenting projects to kids."

Peggy Temple
Teacher

The Design and Discovery curriculum was implemented at John F. Kennedy (JFK) Middle School, a public school located in Hudson, Massachusetts, a community of about 16,000 located near Boston. Sustained school improvement efforts have resulted in a positive learning environment. Teacher teaming, service learning, and flexible scheduling are among the many strategies supporting the learning needs of about 420 middle school students in grades six through seven. This is one example of how the Design and Discovery curriculum has been successfully implemented into a school program.

Program Structure

JFK Middle School math teacher Peggy Temple first learned about the Design and Discovery curriculum at a presentation at the Educator Academy as part of Intel International Science and Engineering (Intel ISEF). She decided it was just the thing that her students needed, and her principal agreed. Because Temple's sixth-grade team operates on a block schedule with 80-minute periods, Temple had the time to do the hands-on activities in class. After reviewing the curriculum, she decided that the design process presented in the curriculum was important for her students to experience. She saw this as a good introduction to the idea of pursuing independent inquiry, something her students would be doing more frequently as they moved through middle and high school.

Temple implemented Design and Discovery as a year-long curriculum as part of her sixth-grade math classes, with a total of 72 students in her four math classes. Every other Friday, her math class was devoted to Design and Discovery. While this schedule allowed a block of 80 minutes at a time for students to work on their designs, Temple would recommend doing the program once a week.

Temple’s science partner, Diane Mason, who also attended the Intel ISEF Educator Academy, collaborated with Temple. As students went between Temple's and Mason's classes, they heard about the design process as it could be applied to math and science. Students developed a common vocabulary which provided connections between the two subjects.
Mentors
Temple involved two different groups as mentors. She tapped into parents and local business people as resources who could offer their expertise with the more challenging engineering activities, such as in the electrical engineering session. This took the burden off of her having to be the expert on all of the topics. She also worked with the Advanced Calculus high school teacher to bring in high school mentors.

High school students in the Advanced Calculus class earned class and community service credit by being mentors for Temple's students. Interested high school students had to apply and were then accepted based on their interest and qualifications. At first, the students helped plan and even taught some of the activities such as where they introduced the SCAMPER brainstorming technique. "These students were so valuable during this time," comments Temple. Later, the mentors were matched with individual students.

High school mentors were given short project descriptions and ranked their project preference. They were then matched with a project. "This worked well because students were not matched according to who they wanted to work with, but rather, by what project interested them," explains Temple. "What I found most astounding was how well my middle school students listened to constructive criticism from other kids—much more than they do from teachers," adds Temple. Mentors and students were so engaged in the projects that they often met after school. "It seems that both the high school and middle school students learned something from this experience."

Standards
For Temple, the Design and Discovery curriculum fit very well into her math curriculum. It addressed many of the sixth-grade math standards, including data collection and analysis, graphing, and surveying. Students used spreadsheet software to create tables and graphs of their survey data. Temple added a marketing element to the curriculum where students used fractions, decimals, and percentages in determining the cost of their product and its marketability. As students determined which materials they were going to use, they applied math skills in a cost analysis. When developing their models and prototypes, they applied measurement skills.

Massachusetts is the only state in the United States that has adopted engineering standards for middle school. The Massachusetts Science, Technology, and Engineering Framework matches well with Design and Discovery goals. It states, "In grades 6-8, students pursue engineering questions and technological solutions that emphasize research and problem solving. Students integrate the knowledge they acquired in their mathematics and science curricula to understand the links to engineering. They achieve a more
advanced level of skill in engineering design by learning to conceptualize a problem, design prototypes in three dimensions, and use hand and power tools to construct their prototypes, test their prototypes, and made modifications as necessary. The culmination of the engineering design experience is the development and delivery of an engineering presentation."

**Assessment**
Temple assessed the students' work throughout her *Design and Discovery* program. She was more concerned about the process than the final product, although she did give a final grade for their design notebook. Temple developed scoring sheets that were used to judge the engineering projects in the school science fair. These were based on similar criteria used to judge at fairs affiliated with Intel ISEF and other state science fairs.

**Science Fairs**
The implementation at JFK culminated in a first-time-ever science fair. Seventy students presented engineering prototypes to parents and community members. Twenty of these students also presented science projects. Student projects were judged and received awards. Projects earning over 30 points got to go to the Massachusetts Regional Science Fair. Eleven projects made it to the regional fair—four science projects and seven engineering projects. This fair draws about 100 projects. To prepare for the regional fair, the seven *Design and Discovery* students did more research and more refinements on their prototypes. Out of the seven who went to the regional fair, four were selected to go to the state fair, the Massachusetts Middle School State Science Fair. With 200 other projects (not all in the engineering category) to compete against, one of the JFK projects earned an Honorable Mention. Temple never expected that her students would get this far. In fact, she didn't even expect to have a school science fair this year.

**Successes**
When Temple presented the idea of *Design and Discovery* to her principal, she established the goal of having a science fair in five years. Well, she met her five-year goal in her first year. "I never expected to have a science fair this year, let alone make it to regionals and the state fair. It all just happened," explains an enthusiastic Temple.

Temple is thrilled with her *Design and Discovery* experience, explaining, "To take kids who knew nothing, and teachers who knew even less, and get to a regional science fair in the first year is amazing. I couldn't have done this without *Design and Discovery*." The curriculum allowed her to be successful teaching engineering and design, even though she has never worked in this field. "I didn't know anything about engineering or design, and it opened my eyes up to a whole different way of presenting projects to kids."
She realized that her students would take to the *Design and Discovery* curriculum when she did the first activity with them, 1A: *Build a Better Paper Clip*. "Students worked on this for a whole week. They came up with everything and all of their ideas were unique! I was amazed," says Temple.

Temple also notes that under-performing students can be successful. "Students found engineering to be fun. They didn't think of this as work. There were no complaints," says Temple.

"For example, one of our lower-achieving students is now considering going to college because of his experience with *Design and Discovery*. He had an idea and created a prototype. Then a professional engineer saw his prototype and is now helping him to file a patent. This is a student who would have probably dropped out of school at age 16," explains Temple.

**Challenges**

For Temple and her students, the greatest challenge proved to be putting together a design notebook that met all of the criteria for the regional science fair. The notebook requirement is intended to teach students to keep all of their work in one bound design notebook, just the way professional engineers do.

Temple also says some students were particularly challenged when their designs didn't work. While they looked great on paper and as prototypes, they didn't necessarily function the way the inventors had hoped. When this happened, students had to problem-solve and come up with new design solutions.