

FIRST
LEGO
LEAGUE JR.

FIRST
LEGO
LEAGUE

Transforming Teaching

A CLASSROOM RESOURCE FOR 21ST CENTURY LEARNING





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About our programs

In 1998, *FIRST*® Founder Dean Kamen and the LEGO® Group's Kjeld Kirk Kristiansen joined forces to create *FIRST*® LEGO® League, a powerful program that engages children in playful, meaningful learning while helping them discover the fun in science, technology, engineering and math (STEM). The program offering has expanded to include the youngest participants through *FIRST*® LEGO® League Jr.

Together, *FIRST* and LEGO® Education strive to inspire young people to create ideas, solve problems, and overcome obstacles, while gaining confidence in their abilities to positively use technology. Students involved in *FIRST* LEGO League and *FIRST* LEGO League Jr. collaborate, cooperate and build the teamwork skills needed for success in a changing workforce.

FIRST LEGO League Jr. | Ages 6-10 (Grades K-4)

The program captures young student's curiosity and directs it toward discovering the wonders of science and technology. This program features a real-world scientific concept to be explored through research, teamwork, construction, and imagination. Guided by adult coaches, teams use LEGO elements to build and LEGO® Education WeDo 2.0 to program a moving model, and develop a *Show Me* Poster to illustrate their journey.

FIRST LEGO League | Ages 9-14* (Grades 4-8)

Children are immersed in real-world science and technology challenges that teach the engineering design process. Teams design their own solution to a current scientific question or problem and build and code autonomous LEGO® MINDSTORMS® robots that perform a series of missions based on an annual theme. Through their participation, children develop valuable life skills and discover exciting career possibilities while learning that they can make a positive contribution to society.

About *FIRST*

The mission of *FIRST* is to inspire young people to be science and technology leaders by engaging them in exciting mentor-based robotics programs from age 6 to 18. These programs build STEM skills, inspire innovation, and foster well-rounded life capabilities including self-confidence, communication, and leadership. Learn more about *FIRST* programs, our teacher support and professional development opportunities at firstinspires.org.

About LEGO Education

LEGO® Education offers playful learning experiences and teaching solutions based on the LEGO system of bricks, curriculum-relevant material, and physical and digital resources to preschool, elementary, middle school and after school. In partnership with educators for more than 35 years, we support teaching in an inspiring, engaging and effective way. Our educational solutions enable every student to succeed by encouraging them to become active, collaborative learners, build skills for future challenges, and establish a positive mindset toward learning. Follow us on Twitter @LEGO_Education.

*Up to age 16 in countries outside the U.S. and Canada.





“

I am extremely proud of my team. We learned that although many goals are hard to achieve, with teamwork, they are not impossible.” –Mehulkumar Gandhi, coach/teacher, San Luis, Arizona

Build STEM interest at your school

Impact studies show that students gain an increased interest in science, technology, engineering and math (STEM) by working with *FIRST* LEGO League Jr. and *FIRST* LEGO League.

As a classroom resource

- Promotes student engagement
- Engages students at different literacy and math levels
- Promotes self-directed discovery
- Encourages hands-on exploration
- Has real-life connections

Develop and apply 21st century learning skills

- Identify relevant sources of information using a range of resources, including digital learning.
- Use language and communication skills
- Work as part of a team, problem solving, resolving conflict, presenting information, or brainstorming

Develop and apply STEM skills

- Develop, evaluate, and modify their design ideas
- Learn about the concepts of input, process, and output and the importance of feedback in control systems
- See how complex systems break down into sub-systems
- Apply their existing math and science knowledge
- Engage in analytical discussions of results
- Understand the Next Generation Science and Engineering Practices, including formulating hypotheses, testing, evaluating and rejecting/confirming hypotheses



FIRST® LEGO® League Jr. Evaluation Study (2014), The Research Group, Lawrence Hall of Science, University of California, Berkeley and Brandeis University, 2013 FIRST® LEGO® League Evaluation

Digital-Age Literacy

*Basic scientific, economic, and technological literacies
Visual and information literacies
Multicultural literacy and global awareness*

- Use of scientific process for problem solving
- Coding, research skills, and technical vocabulary
- Annual real-world, globally significant themes
- A variety of research methods and resources

Inventive Thinking

*Adaptability, managing complexity and self-direction
Curiosity, creativity and risk taking
Higher-order thinking and sound reasoning*

- Coaches and teachers to lead and mentor the students who do the work
- Experimentation and problem solving to develop viable solutions

OUR PROGRAMS TEACH 21ST CENTURY SKILLS

Effective Communication

*Social, emotional and interpersonal skills learning
Personal, social and civic responsibility
Interactive communication*

- The *FIRST*® Core Values teach teamwork, collaboration, and *Gracious Professionalism*®
- A variety of presentation methods and skills

High Productivity

*Prioritizing, planning and managing for results
Effective use of real-world tools
Ability to produce relevant high quality products*

- Time management and project organization to accomplish goals in an 8- to 12-week period
- How to create models and prototypes to demonstrate innovative solutions



PROVEN, VERIFIABLE, IMPACT FOR PARTICIPANTS IN FIRST LEGO LEAGUE JR.**

-  **98%** SHOWED GREATER AWARENESS OF STEM
-  **85%** WERE BETTER ABLE TO EXPLAIN IDEAS
-  **71%** COULD PROBLEM SOLVE
-  **88%** SHOWED TEAMWORK SKILLS

Looking toward the future

Our programs are effective and engaging learning tools for girls and boys. According to many studies 80% of jobs in the next decade will require STEM, technology, programming and robotics skills! Education institutions around the world are seeking strong and motivating platforms for students to pursue STEM-related fields?

Recent OECD findings suggest that worldwide education policies are increasingly serving the need for diverse and complex skills in innovative activities. STEM-related interventions are beginning to foster the required creativity and thinking skills, alongside entrepreneurial capabilities³ Despite large efforts to narrow the gender gap in STEM education, the gap has persisted. However, UNESCO reports that the socialization of the subjects, and ensuring equal access to fun and engaging STEM initiatives, will allow boys and girls to benefit from these opportunities⁴

In our programs, we take all these findings to heart. *FIRST* is an ideal way to transform your teaching as it puts a real-world, relevant context at its core, encouraging students to find creative solutions to open-ended problems. Each challenge comes with our world-class support materials and extensive network of teachers, coaches, volunteers, and experts. Children across a range of ages and backgrounds develop the important skills of communication, collaboration, and critical thinking, while building character. Be part of a fun and social program, proven to grow STEM awareness and skills for the future⁵

PROVEN, VERIFIABLE, IMPACT FOR PARTICIPANTS IN FIRST LEGO LEAGUE**

-  **98%** IMPROVED PROBLEM SOLVING SKILLS
-  **95%** INCREASED TIME MANAGEMENT SKILLS
-  **93%** INCREASED CONFLICT RESOLUTION SKILLS
-  **OVER 76%** STRENGTHENED COMMUNICATION SKILLS

1. Massachusetts STEM Advisory Council 'Why the Focus on STEM?', 2011
 2. US Bureau of Labor Statistics, 'Occupational employment projections to 2018, November 2009
 3. The Organisation for Economic Co-operation and Development (OECD), 'Strengthening education for innovation, 2017
 4. UNESCO, Cracking the code: girls' and womens' education in STEM, August 2017
 5. *FIRST* and The Heller School for Social Policy and Management, Brandeis University, Evaluation of the *FIRST* LEGO LEAGUE Senior Solutions, 2017

***FIRST*® LEGO® League Jr. Evaluation Study (2014), The Research Group, Lawrence Hall of Science, University of California, Berkeley and Brandeis University, 2013 *FIRST*® LEGO® League Evaluation

At-a-glance



<p>Overview</p>	<p>Guided by adult coaches and <i>FIRST</i>® Core Values, teams design and build a Team Model based on the Challenge, using LEGO® Education WeDo 2.0 to program it to move. They illustrate their research and journey in a <i>Show Me</i> Poster, sharing what they learned.</p>	<p>Guided by adult coaches and <i>FIRST</i>® Core Values, teams design their own solution to a real-world problem and build and code autonomous LEGO® MINDSTORMS® robots that perform a series of missions based on an annual theme.</p>
<p>Season Information</p>	<p>Registration Open: April–March Challenge Release: August 1 Event Season: October–June</p>	<p>Registration Open: May–September Challenge Release: August 1 Event/Tournament Season: November–April</p>
<p>Grades & Ages</p>	<p>Grades K-4; Ages 6-10</p>	<p>Grades 4-8; Ages 9-14* <small>*Up to age 16 in countries outside the U.S. and Canada.</small></p>
<p>Team Composition</p>	<p>2-6 children and adult coaches</p>	<p>3-10 children and adult coaches</p>
<p>Time Commitment</p>	<p>Twelve one- to two-hour sessions</p>	<p>8-12 weeks, one- to three-hour sessions</p>
<p>Product Needed</p>	 <p>LEGO® Education WeDo 2.0 (reusable) Inspire Set (annual) Registration options available in single teams and multi-packs.</p>	 <p>LEGO® MINDSTORMS® Education EV3 Robot Kit (reusable) Challenge Set (annual) Registration options available in single teams and multi-packs.</p>



I see a lot of confidence building. I even see it in the hallways. I think team members are more apt to take on leadership roles in schools.” –Andrea Weiss, coach/teacher, Camdenton, Missouri



How does *FIRST* LEGO League Jr. work?

- Design and build a Challenge-related model and use entry-level block-based coding to make it move using LEGO® Education WeDo 2.0
- Create a *Show Me* Poster and practice presentation skills
- Explore challenges facing today's scientists
- Apply real-world math and science
- Begin developing teamwork skills
- Celebrate successes and demonstrate learning in expos
- Engage in team activities guided by *FIRST*® Core Values

Each challenge has four essential components



Explore a problem.



Create one or more solutions.



Test the solutions.



Share what you learn.

How does *FIRST* LEGO League work?

Students work on teams to build and code LEGO-based robots and develop research projects based on a real-world Challenge that changes annually. Their activities are guided by *FIRST*® Core Values.

- Strategize, design, build, code, and test an autonomous robot using LEGO® MINDSTORMS® technology
- Create innovative solutions to challenges facing today's scientists
- Apply math and science concepts to real-world problems
- Develop 21st Century Skills and Social Emotional Learning Competencies, including critical thinking, time management, collaboration, and communication while becoming more self-confident
- Become involved in their local and global community
- Participate in official tournaments and local events
- Engage in team activities guided by *FIRST* Core Values



Our Core Values

The *FIRST* Core Values are the foundation of both programs and differentiate us from other STEM offerings. By embracing the *FIRST* Core Values, participants learn that friendly competition and mutual gain are not separate goals, and that helping one another is the foundation of teamwork.

We express the *FIRST* philosophies of *Gracious Professionalism*® and *Coopertition*® through our Core Values:

- **Discovery:** We explore new skills and ideas.
- **Innovation:** We use creativity and persistence to solve problems.
- **Impact:** We apply what we learn to improve our world.
- **Inclusion:** We respect each other and embrace our differences.
- **Teamwork:** We are stronger when we work together.
- **Fun:** We enjoy and celebrate what we do!





Getting Started with *FIRST* LEGO League Jr.

P R E - S E A S O N

Before you begin, you will need to register and order products, form your team (up to 6 participants) and introduce the children to LEGO® Education WeDo.

S E S S I O N S

Learn about the Challenge theme and Core Values.

Explore the Challenge.

Prepare to share Team Model and *Show Me* poster.

1-4

5-7

8-9

10-12

Learn to work as a team.

Build on coding skills using LEGO Education WeDo.

Create and Test a solution to problem. Build Team Model.

Attend an event and celebrate.

Getting Started with *FIRST* LEGO League

P R E - S E A S O N

Before you begin, you will need to register and order products, form your team (3 to 10 students) and build a Robot Game table. If you plan to compete at an official event, check with your local *FIRST*® representative about dates and details.

W E E K S

Learn about the Challenge. Build Mission Models. Set season goals.

Design robot strategy. Identify a Project problem.

Read rubrics. Test robot strategy. Design Project solution.

Share team's work. Gather feedback. Refine as needed.

1

2

3

4

5

6

7

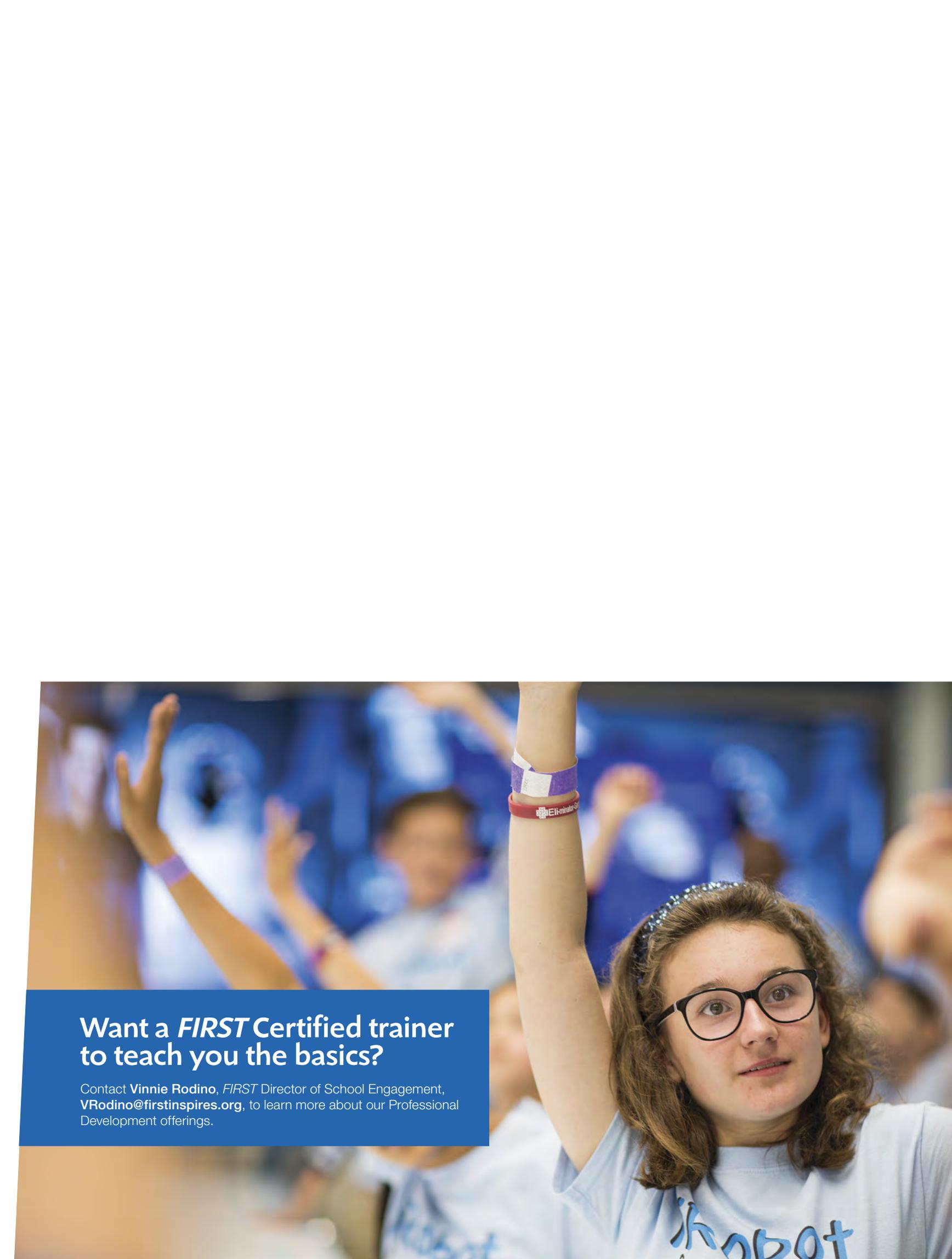
8

Brainstorm possible Project ideas. Select Mission(s) to solve.

Practice robot control. Research existing solutions to Project problem.

Create Project presentation and event materials.

Attend an event and celebrate.



Want a *FIRST* Certified trainer to teach you the basics?

Contact Vinnie Rodino, *FIRST* Director of School Engagement, VRodino@firstinspires.org, to learn more about our Professional Development offerings.



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CASE STUDY | Our Core Values



CORE VALUES

Yucca Cool Cats grow and learn together

While science, technology, engineering and math (STEM) programs abound in the marketplace, *FIRST*® LEGO® League Jr. and *FIRST*® LEGO® League are notable for their foundation in the *FIRST*® Core Values, which emphasize inclusion, teamwork and fun. The lessons of these Core Values provide even the youngest students a chance to grow and succeed.

During the summer of 2016, **FIRST LEGO League Jr. Team 4378, The Yucca Cool Cats**, transformed an unused outdoor courtyard into a colorful school garden to be used by their peers — inspired by their work in the WASTE WISESM Challenge. Their project helped the team of first- and second-graders develop 21st century skills in research, project management and networking with outside experts, while also significantly improving their school environment.

The team from Alamogordo, New Mexico worked together to select a piece of trash and learn about what happens to it after it is thrown away. The team chose

an apple core and learned from their research together that apple cores can be composted. They also learned that compost helps make great garden soil. When it came time to create their team model, they chose to represent school — adding a garden, compost bins, and flowers that “grew” (thanks to the help of a simple machine).

Their project, which was included in the 2016 *FIRST* LEGO League Jr. World Festival Expo, caught the attention of the Otero County Master Gardeners, who encouraged the team to submit a grant proposal. The team received a \$500 grant to make the modeled garden a reality.

The team did the work themselves to make the garden a reality, drawing on coaches and mentors to help them. Under adult supervision, they worked through the heat of summer to spray-paint donated tires and repurpose them as planters designed as storybook characters. The team also planted seeds and plants from local hardware stores. Team member Briar

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said building the garden was hard work, and exciting. “The spray-painting part was fun because you got to do fun things that your parents usually wouldn’t let you do,” Briar said.

The Yucca Cool Cats worked together, helping each other out while showing respect and kindness throughout the project. Most importantly, the children had fun while learning and contributing to their community. Coach Heather Kangas said the students were really invested in the project and made it their own. “The kids love every aspect to *FIRST* LEGO League Jr. They love the research, and then bringing it full circle and actually implementing something really impacted all of them,” she said.

Now that the garden is finished, the Yucca Cool Cats are sharing their knowledge and experience with the larger community. During the school year, classrooms use the garden for lessons. The team is also applying for another grant to buy an automatic waterer and they’re exploring ways to set up composting at school.

“The thing I really love about *FIRST* is that it sparks their interest,” Kangas said. “If you find their interest and passion, it’s just amazing to see because they take it farther than you would ever, ever anticipate it going.”

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— Coach Heather Kangas
FIRST LEGO League Jr. Team 4378
The Yucca Cool Cats

CASE STUDY | The Project



Teamwork solves a waste management challenge

Because of the visibility of the Robot Game, some newcomers are surprised to learn *FIRST*® LEGO® League includes a Project component. As part of their season, teams must identify a problem related to the annual theme and then work together to design an innovative solution to that problem. *FIRST* LEGO League works with professionals in the field to identify some common problems related to the annual theme, and those stories become the basis for the models and missions of the Robot Game. Many teams turn to those missions for inspiration on their Project problem but the sky is truly the limit for teams whose imagination and motivation are captured. While the Robot Game may be the hook that attracts students to the program, it is often the deeper STEM learning of their Project and their interaction with real-world professionals that truly ignites long-term interest.

In the TRASH TREKSM season, on a visit to their local recycling center as part of their Project research, **Ashton Cofer** and his **Incredibots** teammates noticed

a troubling problem. The center couldn't recycle Styrofoam, one of the modern world's most common—and toxic—by-products. "Styrofoam is so cheap to manufacture that it's just not economically viable to recycle it," says Cofer. "It's just a lot easier to make more of it."

With Styrofoam clogging landfills, washing up on beaches and threatening the environment, Cofer and his teammates decided to take action. They decided on their Project problem: how to recycle and reuse Styrofoam. What they didn't know at the time is that this problem has been one scientists and environmentalists around the world had been struggling to solve.

Cofer and his team combed through written research for ideas about how to recycle Styrofoam. There was so much research that they had to divide it up among team members, with each reporting back on what they had learned. "One of the things we noticed was that Styrofoam was composed of over 92% carbon," says Cofer. "That was the spark

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of our idea, to be able to convert the Styrofoam into activated carbon.”

“Activated carbon is the most common material found in water filters,” Cofer explains. “If you have a Brita water filter, you may have seen little black pellets inside. That is activated carbon. Activated carbon is a material that uses very small micropores to effectively filter out contaminants.”

With the help of their coaches and mentors, the Incredibots worked through a series of experiments to try to convert Styrofoam into activated carbon. An early idea involved using an outdoor grill to heat the material — occasionally with fiery results. Later they tested additional treatments like soaking the heated Styrofoam in phosphoric acid to etch away the surface of the carbon.

Cofer and his team did as much as they could by themselves, but also reached out to experts to finetune their ideas. Alan Roy at Calgon Carbon, a leading manufacturer of commercial activated carbon, became a mentor. “He was able to advise us on the different ways that they currently produce activated carbon from coal, which helped us in figuring out a way to produce activated carbon from Styrofoam,” says Cofer.

In the end, the Incredibots developed an effective process for turning Styrofoam into activated carbon.

The team took top honors in the *FIRST* Global Innovation Award, and by the time they reached the finals for this *FIRST* LEGO League post-season competition, they had created a prototype water filter using their activated carbon, a coffee filter and a water bottle to purify the water. The

team used their \$20,000 (USD) award to apply for a patent for their process. Cofer is currently talking to activated carbon manufacturers, including Calgon Carbon, about commercial applications for their process. “The people at Calgon were really impressed,” says Cofer. “They said our process definitely could work in their carb facilities since it uses a lot of the same techniques they’re currently using to produce activated carbon.”

Cofer and his teammates are still refining their process so that the activated carbon works more effectively in removing contaminants from water. They are excited about introducing their invention to the real world, where companies can use a plentiful, free resource that is currently wasted to create clean water. “Not only are you saving money from not having to pay for raw material, but you’re also saving the environment,” says Cofer.

Cofer says that participating in *FIRST* LEGO League taught him and his friends about the engineering design process, while also instilling the resiliency needed to see an idea through to a final product. “I think one of the biggest skills we learned was perseverance, when designing solutions and conducting experiments,” he said. “But a lot of it was having confidence in ourselves. This was a solution that no one had ever done before. We definitely doubted ourselves a couple of times, thinking that this isn’t going to work. But we learned a lot about having confidence in yourself and trying to do things that no one else has done.”

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— Ashton Cofer
FIRST LEGO League Team
Incredibots

CASE STUDY | The Robot Game



ROBOT GAME

Robotcats rookie season plants seeds for growth

For many teachers, the robot can be the most intimidating part of the *FIRST*® LEGO® League experience. While the robot and Robot Game are the most visible parts of the annual Challenge, a suite of tools behind the scenes are waiting to support new coaches — with or without engineering or coding backgrounds. Because the students do the work with the guidance of their coaches, it's best to keep adult hands off the equipment whenever possible. The process of trying and failing and the resiliency and teamwork learned is just as meaningful as the coding and design skills. Once the students have a taste of success and ownership, their confidence grows in visible ways.

Just ask **Alan Metzger, Director of Technology Integration & Innovation Lab** at the **ChristChurch School in Fort Lauderdale, Florida**. In the spring of 2017, Metzger took fourth- and fifth-grade rookie *FIRST* LEGO League teams

to qualifying competitions for the first time ever — and surprised everyone with success. The fifth-grade team won a Core Values award, while the fourth-graders picked up a Judges Award. That was a big win for the fledgling program, but Metzger says that the really important victory was a more personal one, in the tremendous growth that he'd seen in students involved in a robotics competition for the first time.

Metzger has been a teacher for 15 years and last year was assigned leadership of ChristChurch School's brand new Innovation Lab, a creative space where students can build robots, explore 3D printing and engage in other types of science and math-based play. A presentation by a friend at another school — Alexis Cobo at the nearby Pinecrest School — piqued his interest in *FIRST* LEGO League. His school's administration liked the way the program fit with its STEAM-based curriculum and green-lit the program.

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Metzger had led robotics-themed after-school clubs before, so there was a built-in constituency. Fourteen families showed interest, and eventually eleven students signed up. While Metzger was fortunate to be able to rely on Cobo for answers to questions, he also turned to the resources provided by *FIRST* LEGO League, including the step-by-step modules with meeting recommendations known as *FIRST*® Steps. *FIRST* Steps breaks the season into digestible modules, with recommended activities for Project, Robot Game, and Core Values work. For teachers and coaches new to this type of hands-on, project-based STEM program, the breakdown of what to do when can be invaluable. Those who need a complete introduction to the LEGO® MINDSTORMS® technology can also turn to a full library of activities and ramp-up projects from the LEGO Education website.

The two teams met once a week for an hour and a half, both at the same time. Metzger spent the early sessions getting the kids comfortable with the robots and basic coding. “We started small and since they were familiar with some block based coding through their weekly computer science classes I used that prior knowledge as a bridge,” he said. “I also provided them opportunities to “play” using the robot and software to create authentic opportunities for them to be able to ask questions as they encountered difficulties.”

But while the robot and technology may be the most intimidating component of *FIRST* LEGO League to the new coach, Metzger said it was building teamwork, in particular, that took some time. “Everybody wants to touch the robot. Everybody wants to code,” said Metzger. “It was a challenge getting them to understand that it was more than just coding the robot.” Metzger used exercises from the *FIRST* Steps to build teamwork. In one exercise, the teams had ten minutes to collectively decide what ten items they

would bring with them to a desert island. In another, they had to figure out a way to pass water across the room, using cups and sponges.

At first, progress seemed chaotic. But then, about six weeks into the program, the dynamic changed. “Once, the kids heard there was a practice competition, there was a shift in ownership of work. They were invested,” said Metzger. “You began to see so much more growth from them, in terms of their drive and persistence and work ethic.”

As the team became more focused, members made big strides in coding skills. “I had students with minimal coding experience that were creating their own programs and successfully completing challenges independently by our competition date,” said Metzger.

Leaders started to emerge. A quiet fourth-grader named Abby began to take an active role in managing the fourth-grade team, making sure that her teammates knew what their assignments were and completed them. A fifth-grader with good coding skills, but a tendency toward distraction, began to focus and lead his team’s activities. Then came the main competitions, and the two teams, competing against other older, more experienced organizations, outperformed expectations. “That was a big victory,” said Metzger. “The kids really felt they accomplished something.”

Metzger is already planning for next year, when he hopes to have just one team that meets twice a week. If he has to have try-outs, he explains, he’ll probably pick the students who do best on teamwork exercises. “Anybody can learn the coding. Anybody can learn the robotics. Really. But the teamwork part, that’s challenging,” he said. “Getting people to sacrifice to doing some of the coding so they would be able to do research, and that was really cool to see.”

The skills that students have developed are also carrying over into their school work. “Since our competition ended, they seem to be carrying themselves more confidently in Computer Science class. Small groups of them have been coming to iLab to do programming during their playground times. C’mon...they are giving up playground to program! Amazing!” said Metzger. “The confidence in their abilities, knowing that it’s okay to work through a problem and encounter challenges, and ultimately sticking with it and experiencing that personal victory really encapsulates the disposition we want our students to have during STEM activities, Computer Science class in our iLab, and in life. Ultimately you can see the transfer from the team to their performance in class.”

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