MATERIALS AND MECHANICS

CHAPTER 4

In this chapter, you'll find an overview of the key hardware and software components for FLL. You will learn what each element does, why it is important, and how it can help your team.

MATERIALS DEFINED

Playing Field

The playing field consists of the LEGO mission models on the mat, bordered by black 2" x 4"s, on a smooth, flat, hard, uncarpeted, level surface (usually a piece of 4' x 8' plywood). You can find all the details for the setup of your playing field on the FLL website.

Support for the playing field and borders may vary. You can use the floor, but most teams use plywood. Some teams put their surface and borders on sawhorses or milk crates, others build a supporting structure. Of course, none of this matters to the robot: only the surface and borders do.

Every team must decide whether to add lighting to its playing field. Instructions for lighting are provided with the table building instructions. There is no way to ensure that your lighting will be the same as the lighting at a tournament, and no way to ensure that the lighting at one tournament will be the same as the lighting at another. That being said, your team can mimic the conditions somewhat by building a table with the recommended fluorescent lighting hanging above it. Teams that use light sensors on their robots need to test in a variety of conditions. The basic details of tournament lighting are available on the FLL website.

A NOTE FOR ROOKIE TEAMS

In your rookie year, you need to purchase two kits: the FLL Robot Set and the FLL Field Setup Kit. In subsequent years, you will only need the Field Setup Kit, as the game and theme will change each year but the Robot Set most likely will not.

Kits

The FLL Field Setup Kit includes:

- Mission models set: exclusive collection of several hundred LEGO elements required to build the mission models to place on the playing field
- Field mat, a 4' x 8' roll-out mat
- Sheet of 3M Dual Lock fastener for attaching LEGO models to the mat
- Building instructions for the mission models on CD

2006 FLL Robot Set Choices

There are two **FLL Robot Sets** available in 2006. Each one contains all components needed to build and program a robot to participate in FLL. Robot sets are the LEGO MINDSTORMS RCX or the new LEGO MINDSTORMS NXT. Each FLL Robot set includes software, the programmable LEGO brick that is the controller of the robot, hardware to download programs from the computer to the controller, instructions for sample robots, three motors, a selection of sensors, and over 700 LEGO elements including gears, axles, wheels, beams, connectors, and much more.

TIP

There are many types of tackle boxes or other storage systems that may work well for storing your team's kit. The prime consideration is allowing a team member to see all the sorted parts at once. The container should also have a good latch to prevent spills.

You can purchase the robot parts necessary to participate in FLL through LEGO retail or educational suppliers, however the FLL Robot Set is offered at a discount to FLL teams. The details of the robot sets are included online at www.firstlegoleague.org.

Software

There are two different types of software (RIS 2.0 and ROBOLAB 2.5.4) provided in your RCX set that allow your team to program your robot. Using one or the other is a personal preference to be determined by your team. For the NXT, there is one software package that combines elements from RIS and ROBOLAB. Additionally, ROBOLAB 2.9 may be purchased separately for use with either the RCX or NXT kit. All three packages allow you to program your RCX in a drag-and-drop manner. You download programs into your robot through the IR tower connected to your computer or to your NXT, using the USB cable provided.

Programming

We chose to omit programming tutorials from this text because there are a number of terrific online resources available, including materials created by Tufts University and Carnegie Mellon University. See the appendix for more information.

The RCX or NXT

The RCX or NXT is technically not a computer, but rather a microcontroller. A computer is a general-purpose device that has a keyboard, monitor, and mouse. You can usually play games or store recipes on a computer. A microcontroller, on the other hand, is an electronic device that is dedicated to some specific task. Your microwave oven has a microcontroller in it to read time and power entries you make and then to control the magnetron that generates the microwaves. Your RCX or NXT may not necessarily do what you want it to do, but it will always do what you tell it to do. We will simply refer to the RCX or NXT as "the controller."

> **TIP**
> Some of the technical terms used in this section will make more sense once you begin using the software.

The controller allows your robot to perform autonomous tasks based on the programs your team creates. Convey to your team that the controller can control (talk), sense (listen), and execute instructions but it really has no thinking capability. Thinking requires a degree of consciousness that the controller does not have. What it can do is follow programming instructions really well. This is a challenging concept, especially for younger children. Often, a younger child will blame the robot when it doesn't execute a task as hoped.

When a controller communicates, or talks, it talks to either a motor or a lamp. It makes the motor run forward, backward, or turn off. It also drives the motors at various power levels. When talking to a lamp, the power level translates to brightness of light.

When a controller listens, it listens to a touch, light, or rotation sensor. Other sensors, such as temperature, are available but are not sanctioned for FLL. Each of these sensors speaks to the controller in a different language. The controller needs to be told which sensor is connected to which port. It can then listen with the right language interpreter. In NXT and RIS, the connection between sensor and port is made from the checkboxes on the various commands. In ROBOLAB, the association is made by wiring the proper modifier port number to the command in question.

SENSORS

Each FLL team may use a maximum of two light sensors, two touch sensors, and three rotation sensors on its robot. When introducing the concept of sensors to your team, you may want to relate sensors to everyday objects and activities. For example, you may ask kids if they would want to use a touch sensor when giving someone driving directions to the grocery store. At first thought, the children often think a touch sensor would be a fabulous addition to a car. Probe a little deeper and find out how their imaginary cars might use touch sensors. “So, would you tell your friend to drive until they hit the front of the store?”

Then, you might suggest using timing. “Would you drive for three minutes until you get there?” After they have offered a few ideas about using timing, probe deeper by suggesting that their friend drives as slowly as your Great Aunt Ruth.

Next, you may want to ask them about using a light sensor to give directions to the store. The kids may suggest that following the double yellow line down the middle of the street is a good idea. Remind them that the yellow line isn’t always available, such as when a car is making a turn.

Finally, introduce the rotation sensor. The rotation sensor measures axle rotations and therefore distance traveled. In some cases, it may be the best singular form of navigation. Use multiple sensors in concert with each other for optimal navigation.

TRY IT

Because the touch sensor has such a small button, find clever ways to engineer a slightly larger bumper to put in front of it. If the bumper hits an obstacle, it then activates the touch sensor. Add a touch sensor to a simple robot. Try to make the robot drive until it hits a wall and then stop.

Touch Sensor

The touch sensor is the simplest of the three sensors. It tells the controller when something is pushing the button on the sensor. You can use it with a program that tells the robot to turn around after hitting a wall or some other obstacle. More advanced teams sometimes use the touch sensor like a shift key on a computer keyboard to branch their RCX programs.

Rotation Sensor

Every car has a speedometer and an odometer. The speedometer tells us how fast, and the odometer tells us how far we have traveled. Odometry is the science of using an odometer to determine one's position. People with visual impairments are often very good at odometry. They have memorized a map of their world in units of steps. They get from place to place by simply counting paces and walking in the desired direction. A MINDSTORMS robot is mostly blind and is a great candidate for odometry.

The foundation of odometry is being able to measure and travel known distances. A simple way to make the robot drive any given distance is simply to turn on the drive motors for a set amount of time. The idea is to turn the

TRY IT

To test your rotation sensor, build a simple robot from the *FIRST* website or another resource. The *FIRST* Place Scooter is an example. Add a rotation sensor to your creation. Try to make the robot drive exactly 12 inches. Try to make it turn 90 degrees using the rotation sensor instead of timing. The number of necessary rotations will depend on the design of your robot. Odometry accuracy may also suffer if you use tracks rather than wheels. The scrubbing of the tracks during turns is not very reproducible. Skinny, high-traction wheels generally provide the best accuracy.

TIP

Using NXT, the rotation sensor is already a part of each motor. With an RCX, you will need to find a way to add rotation sensors to your robot. When adding a rotation sensor, make sure it doesn't bind the axle, making it difficult for that axle to turn. We recommend letting the sensor wiggle like a loose tooth. It may have LEGO's standard studs on top, but this does not necessarily mean you should lock it to another brick. Instead, you might allow it to hang freely from the axle it's measuring.

motors on, delay, then turn off the motors. By adjusting the time, you can adjust the distance traveled. You can perform turns in a similar way. Simply turn one motor on, delay, and then turn the motor off. It is important to keep in mind that by relying on timing, your team sacrifices accuracy as batteries wear out, slowing the motors and reducing the distance traveled.

> **TIP**
> If the team opts to make a change to its robot's chassis, existing programs using the rotation sensor may be affected.

You can find a solution to these problems by using a rotation sensor. Adding a rotation sensor to the robot's drive train will act like the odometer in your car. It keeps track of exactly how far the robot moves. For the RCX, each full rotation of the axle that passes through the rotation sensor increases its count by 16 units, just like the hands sweeping around a clock, which uses 12 units instead of 16. For the NXT, measurements are made in degrees, with 360 for each motor rotation.

Your team members may find the concept of rotation sensors a little challenging at first. Often kids think that 16 rotations equal 16 inches. This is not so. The relationship between rotations and inches depends on the gearing and wheels on your team's robot. You can use the controller to determine how many rotations are needed to move the robot a desired distance.

Using the rotation sensor to make precise turns will provide teams with a challenge. Some teams make their robot turn by leaving one motor on while turning the other off. You can also program one motor to run forward while the other runs in reverse. Test these methods with your robot. What works best depends on your chassis design and the task you want to accomplish.

Rotation sensor odometry has various degrees of accuracy. To increase the accuracy, you want the rotation sensor axle to turn at a faster rate than the wheel.

There are upper limits on the number of RPMs a rotation sensor can measure accurately. A good rule of thumb is to have the rotation sensor rotate at the same speed as the motor, or about 300 RPM.

Q: Is there a good reason our team is not allowed to use additional sensors, because compared to the expense in time and effort spent on FLL, the cost of additional sensors would be trivial?

A1: You could have 50 rotation sensors and not be able to get accurate turns. You could have a radar sensor on your robot and still crash into the wall. There are both mechanical and programming solutions to these issues; encourage your team to come up with different ways to solve the problem.

A2: Perhaps, but a good engineering challenge always has some kind of limitation to make you think hard about out of the box solutions.

Q2: Is there a good reason our team is not allowed to use the new ultrasonic sensor on the NXT?

A: There are teams with the RCX set who do not have this sensor and our tournaments must be as fair as possible.

Light Sensor

If you look at a light sensor closely, it looks like it has two tiny light bulbs in it. In fact, one is a light bulb and the other measures, on a scale of 1 to 100, how much light is reflected back to the sensor. A dark surface gives a much lower reading than a light surface, a white surface, or aiming the sensor at a light bulb.

Being able to have a robot follow a line on the field mat can be very valuable. To follow a line, the robot must sense it by using a light sensor. Place it just above the mat looking down. The software must now use the varying light intensities reflected back from the mat to turn the robot.

In the 2001 and 2002 Challenges, robots could accomplish many major tasks by following lines on the mat. In the Arctic Impact Challenge in 2001, black leads, or ice cracks, could be used as roads to most of the major tasks. When traveling over the ice, the controller reading was a large number, when over a crack, a smaller number. Pointing a light sensor downward allowed the RCX to see or follow the line.

TRY IT

Program your RCX to recognize the light sensor on one of the three sensor ports (1, 2, or 3). Hit the “run” button twice and the “view” button to take readings on a dark surface, a light surface, and with the sensor aimed at the sun or a bright light.

There are numerous ways to write a line following program, or algorithm. Depending on circumstances, some work better than others. The same algorithm executing on different robots operates differently because each robot has varying agility and the sensitivity and placement of the light sensors is different. Just as it's not possible to drive a car forward looking out the rearview mirror, the light sensor must be near the front of the robot as it travels.

TIP

As a coach, you need to help your team strategize ways to solve the problem of unpredictable lighting on the spot. Some possible solutions are:

1. Follow the KISS principle and abandon the use of the sensor.
2. Shield the sensor from as much ambient light as possible.
3. Select average values and hope for the best.
4. Carefully calibrate the software to the conditions at the venue by taking readings at each table.
5. Have the robot self-calibrate. That's an advanced solution for sure!

Proper positioning of the light sensor is also important. You must have a good variation in return values between differing shades. To work well, a light sensor with an RCX should be about the thickness of two pennies from the surface of the table and it should always be in the robot's shadow. A light sensor that is hidden from the ambient, or surrounding, light of the room works most reliably under most conditions. The light in your practice area will vary from the lighting at the tournament, so it's important to test your robot under different lighting conditions.

The simplest line following algorithm is perhaps the "shades of gray" approach. When you want your robot to follow a black line on a white surface, you see a very sharp contrast between the white and black. The light sensor does not. As the light sensor is moved onto the line, it first sees white, then increasing gray before seeing the final black. This is because the light sensor averages the color over a finite area. When the sensor is properly placed on the robot, this area of light emitted is about the size of a pea on the surface of the table.

Every team using light sensors is likely to face ambient light challenges. A line following robot works great sometimes and not at all at other times. This does not mean you should avoid using light sensors. FLL has standardized the lighting of the competition tables in an attempt to minimize this problem. As the table instructions on firstlegoleague.org outline, we place a fluorescent light fixture a fixed distance from the playing surface, centered over the mat. This minimizes the variables from site to site but does not eliminate them completely.

Ambient lighting from high-pressure sodium vapor (HPSV) lights in a gymnasium may be quite different from the fluorescent lights in your practice area. Even with the regulation competition lights directly overhead, the light intensity at the table surface differs from venue to venue. It is also likely to vary within the same venue. If one competition table is directly under an HPSV and another is not, the light values returned by the same sensor will differ by a few counts.

Object Manipulation

Besides moving from place to place, an FLL robot has to manipulate playing field objects. Manipulation is perhaps the hardest aspect of the FLL Challenge, especially for newer teams. What looks simple to humans can be extremely difficult for a robot. In the early stages of the Challenge, coaches often hear the team say, “We will simply pick up the gizmo and zoom over there and dump it.” Reality quickly sets in after the first few ideas fail.

Each Challenge requires several types of manipulation against a variety of objects. These may include lifting, dropping, dumping, pushing, dragging, and other actions. One manipulator is unlikely to solve all the missions.

Assuming you used two motors for locomotion, you are left with only one for manipulation. How can you solve all the missions with only one manipulation motor?

There are several solutions:

- You do not have to solve all the missions. One strategy is to solve a few of the high-scoring missions reliably rather than all of them 20 percent of the time. Here is a chance to teach the team members some simple probability or game theory. Strategy matters. Not all manipulations require an electric motor. Some solutions can be remarkably simple using purely mechanical devices. Think in terms of a mousetrap or other trigger activated devices.

- Consider a generic motor assembly to which you can connect various manipulators as needed.
- Modify the robot while it is inside the base. One FLL team rebuilt its detachable manipulator during the execution of another mission. We have also seen a modular robot be radically reconfigured in the base. This is an unconventional, but workable, solution and presents its own challenges.

Q: Does the timed round include time used changing parts, etc?

A. Yes. There is no timeout mechanism, so make sure any attachments are easy to add under pressure.

The biggest challenge with manipulators is the team members' lack of experience with mechanisms.

Here are some ideas to get them up to speed:

- Many of the LEGO MINDSTORMS books have lots of great designs to use.
- Search the web for LEGO creations.
- Make a field trip to the local hardware store to look at their forklift trucks and scissor jack platforms. If you call ahead, they may give you a demonstration.
- While at the hardware store, look for other gizmos to inspect. Wander the aisles with an open mind.

REMINDER

Engineering is the process of gathering from the best current designs and combining them into your own. There is no shame in building on other peoples' work.

- Look at cranes, dump trucks, backhoes, and front loaders for inspiration. If you meet in a library, look through books that deal with machines or check out a few books and bring them to your team meetings.

After the team has researched mechanisms for a while, brainstorm, then prototype the selected ideas. Do not waste time trying to get a perfect working model right away. What you learn from the quick and rough prototype may completely change your approach. Try to get multiple sub-teams working on various solutions simultaneously. Competition and learning can be effective motivators.

Try to minimize the weight of the manipulators. Large heavy accessories bog down the robot, waste batteries, and cause navigation to become less predictable and repeatable. Consider building long or tall devices out of axles rather than bricks. LEGO sells bags of axles and connectors that are great for this purpose.

Remember that you may leave manipulators or accessories on the field. They do not have to be attached to your robot and/or returned to the base. Pushing something out on the field and leaving it there is currently an acceptable solution, but be sure to check the rules for the year's Challenge.

Encourage your team to look hard for simple solutions. These solutions will work consistently at a tournament.

RCX Battery Replacement

This section includes helpful information for changing the batteries in the RCX, and does not apply to the NXT. The batteries are a critical part of the RCX. If you're using an RCX and it's time to replace the batteries, you can lose the firmware along with any saved programs (similar to a computer's operating system) if you do the process carelessly. It's easy to download the firmware again, but if you have programs stored on the RCX that are not saved on your team's computer, or the computer is unavailable, such as at a tournament, your team will experience unnecessary frustration. The NXT uses Flash

> **TIP**
> For environmental reasons it is good to use rechargeable batteries whenever possible.

memory and should not lose data if the batteries are removed or drained completely.

If your team is using the RCX, have team members learn the system for changing the batteries. The kids should learn two things:

1. Do not build a robot that must be completely dismantled to gain access to the battery compartment.
2. The second is how to change the batteries fast enough so you do not lose the firmware or the stored programs.

Changing batteries is best accomplished as a two-person job. One person will remove the batteries one at a time. The second person will manage the new and old batteries. Practice this with many team members.

- Open the RCX to expose the batteries.
- Use a permanent marker to scribble over the batteries to mark them as used.
- Change the batteries one at a time to retain the firmware.
  - A. Remove a marked battery.
  - B. Very quickly, add a new one in its place.
  - C. Wait a few seconds before switching the next battery to allow a capacitor inside the RCX to charge, giving it the power to run for the next 15 seconds.
  - D. Repeat this process until you have changed all batteries.

If you leave any individual battery out for longer than about 15 seconds, you risk losing the firmware and programs. If you confuse the batteries during the change, do not panic! Put any battery into the RCX. Now it's a simple matter to look for the marker scribble to determine the old batteries.

TIP

Brand new alkaline batteries are super-charged for about 10 minutes of use. At this point they provide the same power for a considerable time before they fall away to nothing. For competition, always check your batteries after every other round. This is especially true if your robot uses time delays for making turns or moving set distances. All of the software types have features to check the battery level.

Programming Garage

Using an RCX, programming your robot can be tricky. If your robot is turned on and sitting on your table, a team 30 feet away may not only program its robot but yours as well. You may not realize the problem because humans can't see the infrared light emitted from the towers. (With the new LEGO MINDSTORMS NXT, a USB cable eliminates these issues.)

TIP

Practice using the programming garage at your meetings so it becomes routine. Many teams have been shocked to find their robot running another team's program at mission time. This is why tournament rules prevent programming inside the robot competition area.

A programming garage solves the infrared problem. Create one by lining a box with aluminum foil to protect your robot and prevent interference from other robot programs. You can use the same box that you use to transport your robot from the programming area to the playing field. Put your tower and the robot under the box when programming. Make sure the robot is turned on only when it is inside the garage or when it is being used.

THE PROJECT

CHAPTER 5

The exploration of the Challenge Project enhances the overall FLL experience. FLL is not just about building and competing with robots.

PROJECT STEPS

Through the research for the project, your team will learn more about the Challenge theme and better understand the work of professionals in that field. Your team will encounter challenges similar to those faced by scientists and engineers. Exposure to these fields of science and related professions will open your team's eyes to future career choices where they can make a positive difference to society.

Find a Problem

Your team will be asked to identify a problem related to the year's theme, research the problem, create a unique engineering or technological solution, and share your findings. It is critical to not only complete all aspects of the assignment to qualify for awards, but it is also important to communicate all aspects to the judges.

Some teams would prefer to concentrate on their robot and eliminate the project. Just as many teams love the project and consider it to be the best part of their FLL season. We believe that every part of the program teaches different, critically important skills. We want kids to be excited about science, technology, engineering, and math. Research and problem solving are an integral part of these fields and key to the success of any real-world engineering team.

TRY IT

As a research activity, have your team members explore Challenge-related professions and brainstorm as many careers in that field as they can.

Create a Solution

As a result of your team's work on the project, you may come up with a number of solutions. The next step is to agree on one solution and how to present it. Make sure the team solution is either new and unique or improves upon an existing solution. If your team plans to compete in a tournament, you need to be able to show the panel of judges that your solution was well researched and thought out.

Prepare a Presentation

If you plan to attend an event or tournament, be sure to prepare for your presentation. If your team needs special equipment, call the tournament organizers ahead of time to see if it will be available. If not, your team is responsible for bringing everything you need. When your team presents its project to a panel of judges at a tournament, they have five minutes, **including setup**. Because the kids are supposed to do all the work, be sure the kids plan a presentation they are able to set up on their own without adult assistance. Props do not need to be fancy. If homemade, they should demonstrate the kids' work.

> **TIP**
>
> The guidelines for the project change each year. Read the project description carefully. Reading the forum on the FLL website may give you ideas about how your team might complete the project. There is no right or wrong answer to the project. By design, it is open ended and allows for creativity and out of the box thinking by the team. It's not about coming up with the right answer. It's about unleashing the team members' power of creativity and seeing where it takes them.

Present your findings in a creative and thoughtful way. We have seen projects presented as songs, skits, radio broadcasts, TV interviews, poems, stories, dances, plays, etc. A judging panel is always interested to see a unique presentation. On the other hand, a presentation without any substance will not receive high marks from the judges. It is a balancing act. Each team must find its own way to show cleverness and demonstrate its knowledge. Refer to the judging criteria section of the awards chapter and the rubrics in the appendix for more details.

Many teams prepare a project brochure or other material to leave with the judges. Like the props, these materials do not need to be fancy. It is a great opportunity for your team to present its project in a short, easily readable format that can be passed out at your pit table to specatators and other teams. If you present a project binder, be sure to ask the judges to give it to the pit administration before the awards ceremony so you can pick it up.

As practice, and to meet the third requirement of the project assignment, you might want to share the findings with your team's parents and relatives, a community organization, or your school.

TIP

Be sure to visit the Project Resources available on the FLL website (firstlegoleague.org) before starting your research. The list can provide helpful websites, publications, and experts in the field of the Challenge theme.

Prepare Plan B

If your team's presentation includes audiovisual equipment, be sure they are prepared to present without it if it fails.

Your team will receive only five minutes to present, and the kids should be prepared to give a presentation immediately if they experience difficulty with equipment. This applies whether a team is using PowerPoint or a DVD. And remember – the entire presentation is only five minutes long, including setup time. This includes the running time of a DVD or other materials. See Chapter 7: The Tournaments for more information about project presentation judging.

A question and answer session usually follows your presentation. Depending on the tournament, adults may or may not be allowed in the project judging area. If adults are permitted to observe, it is important they do so without interfering. If the judges are unable to adequately judge the children's actions, it will reflect on the team's score. Make sure the team is able to perform the setup and tear down without a lot of fuss or adult help, as the next team will be waiting at the door as your team presents to the judges.

Q: Is the emphasis on the proposed solution for a team's research project supposed to be futuristic or visionary, and do you need to build a working prototype?

A: You could add a twist to take a common device to the next level, and no, you do not have to build a working prototype. A cardboard model or a nice drawing would be appropriate.

CHAPTER 6

CELEBRATING YOUR FLL SEASON

At the end of the *FIRST* LEGO League season, your team should be proud of its accomplishments. Your team members created a unique project, designed and programmed a robot to perform difficult tasks autonomously, and learned how to work together successfully. It's important to celebrate what you've done together.

CELEBRATIONS

Many teams celebrate at tournaments; others celebrate in their own way. Do what works best for your team, but be sure to include a plan for celebration in your schedule.

Host a Local Event

Some teams choose to attend an FLL Championship tournament, sponsored by the local FLL Partner. We outline different types of tournaments in Chapter 7: The Tournaments.

If your team does not attend a qualifying or Championship tournament, you could host your own local event and invite other teams in the area to attend. You may do this in addition to attending qualifying or Championship events. Visit the Tournaments section of the FLL website (firstlegoleague.org) for a Local Event Guide with complete instructions for running your own FLL event from start to finish, including instructions for posting your event on the FLL website.

You can customize local events to suit your team's needs and resources. The flexible format for local events allows you to include elimination rounds, special robot challenges, teamwork activities, mini-projects, and other special components your team develops.

If you host a local event, you may see team members learn new skills and take more responsibility for their work because they are running the event. Kids consider the local event a showcase for their FLL accomplishments, and they love the opportunity to see what other teams have done with their robots and their projects. Sometimes host teams participate in the competition but choose not to be eligible for an award, enjoying it for the experience rather than for competitive reasons. Whatever your team chooses to do, let other participating teams know what they can expect.

Recognize Your Team Members

Plan your own celebration. Invite family and friends to see what your team has accomplished. Ask your school to hold a special assembly or your sponsoring organization to hold a team social. The team can display its project, demonstrate its robot, and showcase team mementos, journals, or photos.

Some teams provide certificates to each team member, with special recognition of the contribution each child made during the season. You can find special FLL certificates with the season's logo on the *FIRST* website (usfirst.org) in the FLL Communications Resource Center. Be creative when awarding certificates, and be sure each child on your team receives one.

As an end-of-the-season teamwork exercise, ask the team to write down what each member contributed. Then present each child with a certificate showing the contributions that other team members cited. You could also ask team members to vote on the future profession they think each team member is most likely to pursue. One child could be Most Likely to Invent Something to Change the World. Another child could be Most Likely to Create a New Computer Program, Most Likely to Run a High-Tech Company, or Most Likely to Be President of a Research Facility. This kind of recognition helps kids understand how their new-found skills and talents translate to the professional world.

Ask the kids to review the list of FLL values and choose the one that each member best exemplifies. This is a great way for the kids to understand that their contributions to the team are greater than the tasks that each one performed. One child might receive a Gracious Professionalism award, and another might receive the Spirit of Friendly Competition award.

A certificate presentation could be part of a larger ceremony with your team. Take a picture of each child with his certificate. You could hold this ceremony as part of a celebration dinner or pizza party. Whatever you do, make it special.

Applaud Your Sponsors, Mentors, and Volunteers

Be sure your team recognizes the contributions of mentors and volunteers at the end of the season. The team can provide its mentor a framed team or robot photograph or a certificate or letter that recognizes the special talents shared. If you want to give a gift with a *FIRST* logo to volunteers, mentors, or sponsors, visit the *FIRST* online store (usfirst.org) for clothing, awards, and other customized items.

Acknowledge Each Person

Whether or not you attend a tournament, be sure to make some one-on-one time for each team member. Tell each one how she contributed to the team. Remind her of the great ideas she had, the problems solved, the way she supported teammates, and the things learned during the season. This is your most important job as a coach, so take time and be thoughtful about what you say to each child.

Salute the Group

Tell the group how their accomplishments as a team were special, innovative, or unique. Tell them what they did that changed you, or changed the way that you think about them. Sometimes it's difficult to say the words, but it's important that the team understands what coaching them has meant for you. Recognizing the entire team, as well as praising each child individually in front of his teammates, will create a lasting memory of working with you and your team on *FIRST* LEGO League.

Now pat yourself on the back. You have had an influence on the lives of these children and expanded their horizons. Congratulations on a job well done.