# TRANSFORMING TEACHING
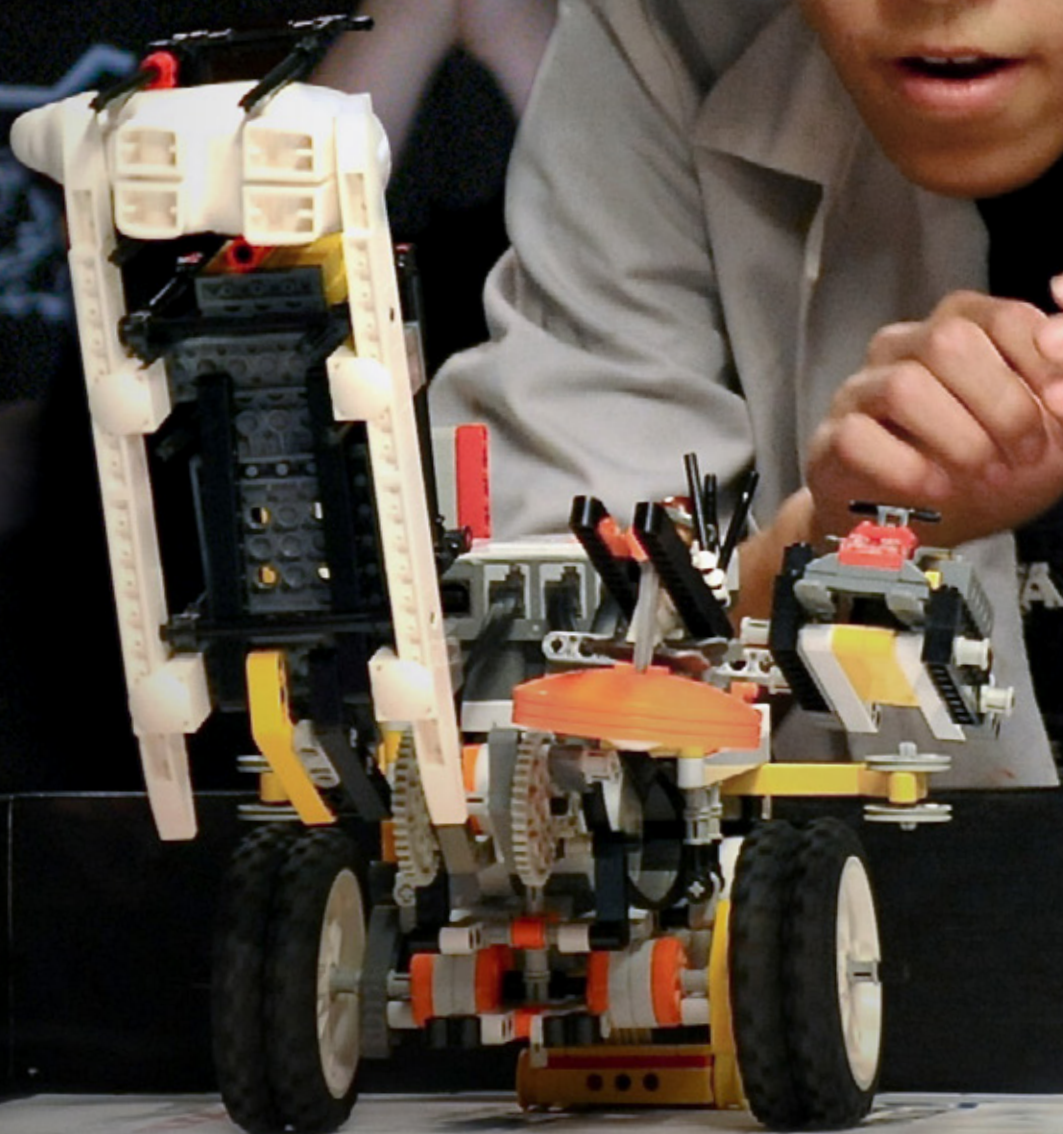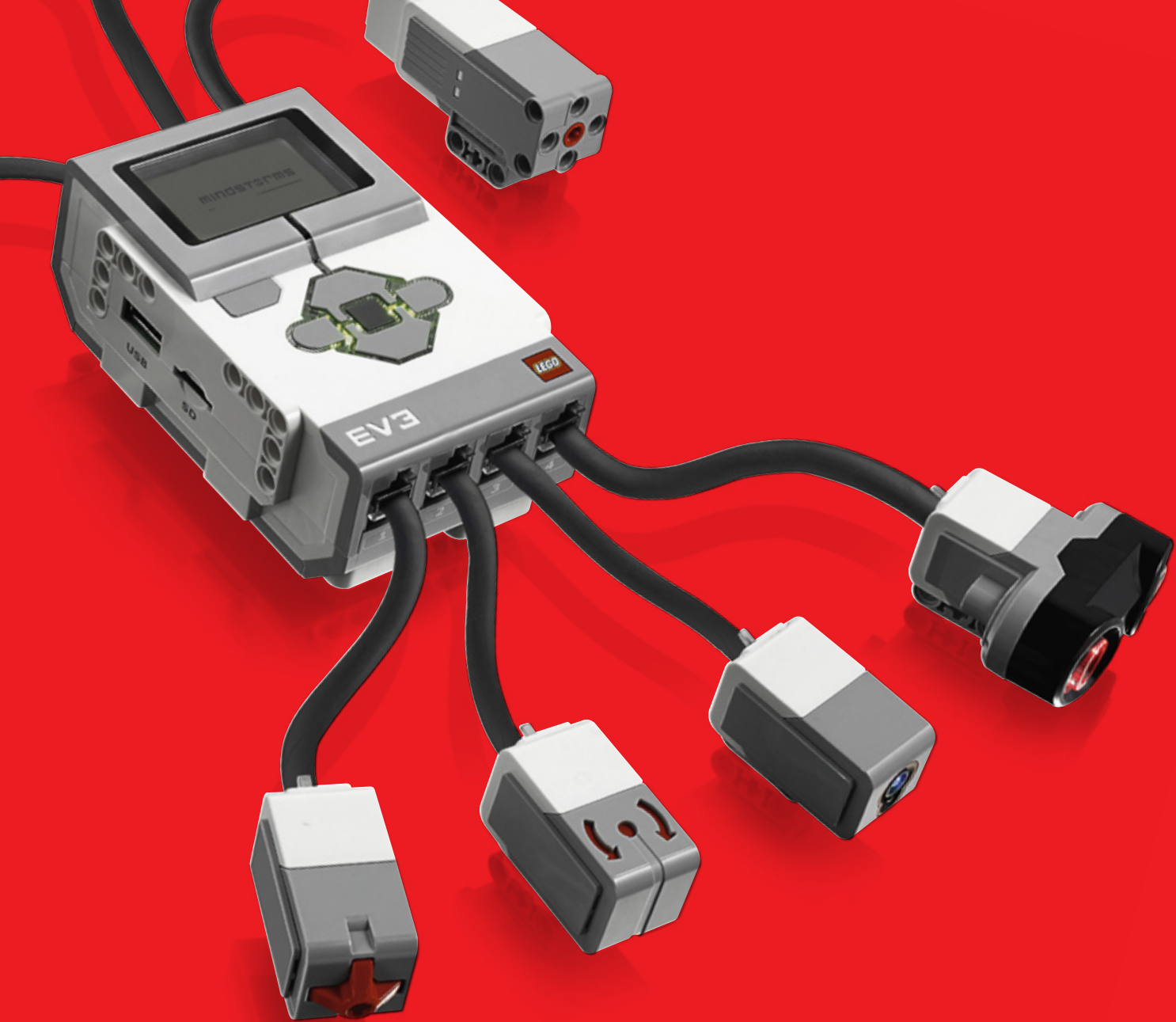
*FIRST*® LEGO® LEAGUE AS A CLASSROOM RESOURCE FOR 21ST CENTURY LEARNING

**FLL**®
*FIRST*® LEGO® League

# Contents

# Documents to inspire you

# Why *FIRST*® LEGO® League is perfect for your school

Impact studies[1] show that students gain an increased interest in science and technology by working with *FIRST* LEGO League (FLL®). FLL does this by providing a practical and engaging way of involving students in the subject areas.

**AS A CLASSROOM RESOURCE, *FIRST* LEGO LEAGUE...**
- Promotes student engagement
- Allows for differentiation
- Promotes self-directed learning
- Encourages hands-on learning
- Has real-life connections.

**YOUR STUDENTS WILL DEVELOP AND APPLY THEIR 21ST CENTURY LEARNING SKILLS TO...**
- Identify relevant sources of information using a range of resources
- Use language and communication skills
- Understand the scientific method of formulating hypotheses, testing, evaluating and rejecting/confirming hypotheses
- Work as part of a team.

**YOUR STUDENTS WILL ALSO DEVELOP AND APPLY THEIR STEM SKILLS TO...**
- 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 maths knowledge
- Engage in mathematical discussions of results.

*" The project acted as a reminder of what I consider to be core as a teacher: when students focus on an idea, when they follow up on it and work on solutions to a problem they have identified, and they conclude with a final, sustainable project where there is a clear connection between theory and practice – you cannot ask for anything more. "*

## Welcome to *FIRST*® LEGO® League!

*FIRST* LEGO League (FLL®) is an international enquiry-based program teaching students ages 9 through 16 about science, technology, and collaborative working.
FLL is a partnership between the non-profit organisation *FIRST* (For Inspiration and Recognition of Science and Technology) and the LEGO Group. It had its first season in 1998. Now over 230,000 students from 80 countries take part.
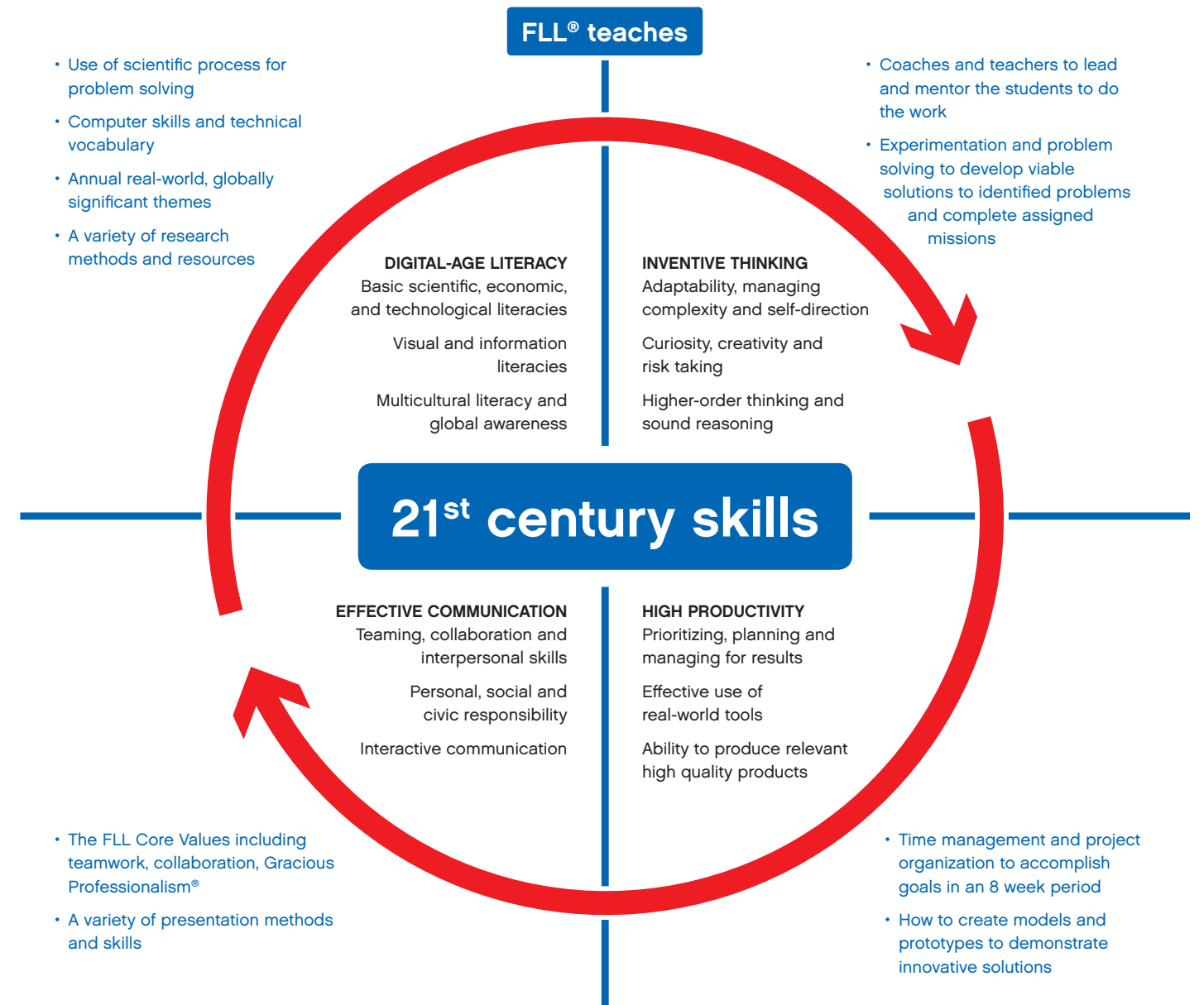
Not only is FLL® an effective and engaging learning tool for both boys and girls. There are wider reasons why *FIRST*® LEGO® League exists. According to many studies conducted during the last 10 years, there is an alarming decline in students' interest in STEM.

**WHY ARE STUDENTS LESS INTERESTED IN SCIENCE?**

One study by the European Commission[2] says that there is a connection between attitudes towards science-based subjects and the way that they are taught. An OECD[3] report on science education recommends that teaching remains rooted in the real world. UNESCO[4] calls for an enquiry-based approach that emphasises the innate creativity of all children.

*FIRST* LEGO League takes all of these findings to heart. It is an ideal way of renewing your teaching as it puts a real-world, relevant context at its heart and encourages students in creative solutions to open-ended problems.

1. Center for Youth and Communities, Brandeis University, September 2009 http://www.usfirst.org/aboutus/impact
2. European Commission, Rocard Report, 'Science Education Now: A renewed Pedagogy for the Future of Europe', 2007
3. The Organisation for Economic Co-operation and Development (OECD), 'Evolution of Student Interest in Science and Technology Studies', 2006
4. http://www.unesco.org/new/en/education/themes/strengthening-education-systems/science-and-technology/hands on-science/

**FLL® teaches**

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

- Coaches and teachers to lead and mentor the students to do the work
- Experimentation and problem solving to develop viable solutions to identified problems and complete assigned missions

**21st century skills**

**DIGITAL-AGE LITERACY**
Basic scientific, economic, and technological literacies

Visual and information literacies

Multicultural literacy and global awareness

**INVENTIVE THINKING**
Adaptability, managing complexity and self-direction

Curiosity, creativity and risk taking

Higher-order thinking and sound reasoning

**EFFECTIVE COMMUNICATION**
Teaming, collaboration and interpersonal skills

Personal, social and civic responsibility

Interactive communication

**HIGH PRODUCTIVITY**
Prioritizing, planning and managing for results

Effective use of real-world tools

Ability to produce relevant high quality products

- The FLL Core Values including teamwork, collaboration, Gracious Professionalism®
- A variety of presentation methods and skills

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

" *It is important to work with FLL in school because the project challenges the children. They get to work outside the ordinary school arena and use learning resources that they seldom encounter otherwise (academic, research and commercial environments). The students acquire knowledge which in turn gives rise to attitudes. They learn to evaluate and make decisions, some of which they may have to reconsider/redo at a later stage.* "

# What is *FIRST®* LEGO® League and how does it work?

FLL® is a project-based programme. Over recent years, students participating in the program have looked at a number of annual 'Challenge' topics. They include:

- Global climate
- How best to help people with disabilities
- Nanotechnology
- Protecting the oceans
- Keeping food safe
- Helping older people stay independent, engaged, and connected.

The Challenges are developed in co-operation with educators and topic experts from academia, business and industry.

### A *FIRST* LEGO LEAGUE CHALLENGE CONSISTS OF THREE PARTS:

- A research assignment called 'The Project' where students research and come up with innovative ideas for solving a defined, real-world challenge
- A 'Robot Game' where students design and program a LEGO® MINDSTORMS® robot to solve missions on a special obstacle course
- 'Core Values', the work process the students go through to obtain important life skills such as problem solving, critical thinking, creativity, and team-work.
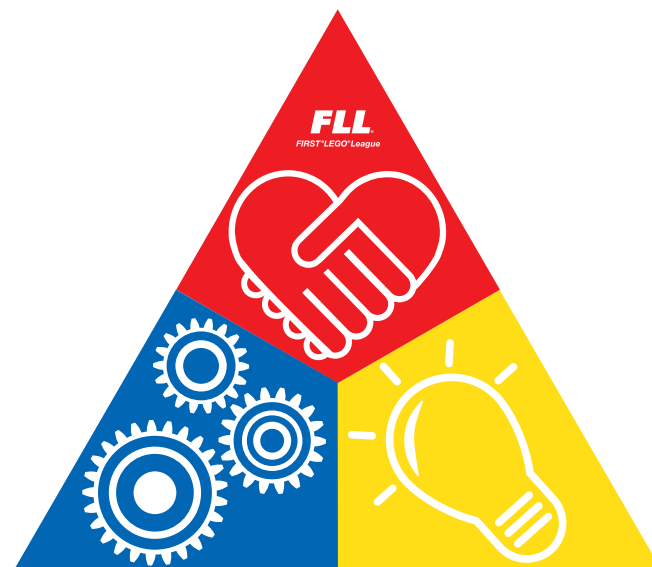


The Project and the Robot Game are what the students do. Core Values are how they do it.

*FLL gives students the possibility of experiencing the joy of exploration and discovery. There is not only one solution to a problem, and it is important for the students to realize this as much of the other school work deals with finding the one and only right answer*

### HOW DOES IT WORK?

The annual programme allows students to experience a creative process in which they are in command. Their task is to solve problems and invent solutions inside a tight time frame – just like in real life. Here are the stages:

- A team is formed comprising up to 10 students and at least one adult coach or teacher
- The team registers with the *FIRST®* LEGO® League partner in their country or region
- The Challenge is announced live on the Internet between late August and early September
- Teams have 8 to 10 weeks to conduct research, come up with an innovative solution to the problem they have identified, prepare and make their presentations
- Teams compete at regional tournaments and present their work to a panel of judges consisting of experts and volunteers
- Winners of regional tournaments advance to national tournaments
- Winners of national tournaments may get the chance to attend international tournaments.

# Making space for *FIRST®* LEGO® League

*FIRST* LEGO League makes an exciting and enjoyable way to engage your class with a range of curriculum areas. Many teachers integrate it with a specific subject, normally science, maths or language. Others will use it as a cross-curricular project. How you choose to employ it is up to you. You will find some suggestions below.

**ORGANISATION**

Teams can have up to 10 members. To give each member the best learning experience, you can register more teams or set up FLL® as an optional class. Feedback from teachers indicates that both of these work well. It can also be planned as an after-school activity or as a school-parent project.

Try allowing everyone to work together in the initial phases of the Project and the Robot Design task. Then hold a 'job fair' and get each student to apply for the job they want to do. This way, you can select the strongest team, the one that gives the most inspiration to certain children or a combination of the two.

Cooperation is integral to *FIRST* LEGO League. If a team is split into smaller work groups, make sure there are regular status meetings. This is also a useful way for the smaller groups to get comments and suggestions from other members of the class.

One of the more effective ways of using FLL is to encourage girls to apply for the robot-related tasks. They tend to choose project-related tasks unless they are encouraged in another direction.

**ACTING AS FACILITATOR**

Create the conditions for the students to tackle the Challenge by acting as a facilitator. Set the stage, manage the process, and encourage the students to reflect on their work. Here are some suggestions for how this may work:

- Setting the stage – set out the rules for co-operation in the team(s) and keep the students motivated.
- Managing the process – gently keep the team moving forward, resolve any conflicts and, most importantly, make sure that all the students are involved during the process and that all students' contributions are equally valued.
- Encouraging reflection – ask questions, but do not provide answers to encourage students to come up with their own solutions. Your questions should be explorative, challenging and motivating.

❝ *Working with FIRST LEGO League gives students a chance to cooperate, to get some qualifications and to transform theory into practice. The concept offers many different tasks ranging from presentations to programming that draw on many different competences.* ❞



❝ *I have seen engagement far beyond what you usually see in class. The students stay several hours after normal school hours. Actually you have to "force" them to leave school.* ❞

**TIME REQUIREMENTS**

Teams will have 8 to 10 weeks between the release of the Challenge online and the first regional tournaments. Here are some ways that you can schedule work on *FIRST®* LEGO® League:

- Spend one full week and then a couple of lessons a week for the remainder of the time
- Spend one or two lessons a week for the duration of the whole project
- Use two solid weeks to work on the programme
- Spend one or two afternoon(s) a week during the project period.

Surveys suggest that teams spend five to six hours a week working on the project. Be aware that new teams or teams with younger members may need more time while older or more experienced teams may need less. Teams often enjoy the task so much that they may spontaneously spend breaks between lessons or time outside school working on the programme.

# Getting started

Once you've decided to join *FIRST*® LEGO® League, it's easy to get started. There are some things you'll need, including a computer, and some things that you will need to do.

**A PC OR MAC**
You will need a computer to:
- Register your team
- Learn more about the Challenge and the rules
- Research the Challenge topic
- Program the LEGO® MINDSTORMS® robot
- Download the building instructions for the Robot Game missions
- Make judging presentations for the FLL® tournament.

**TEAM REGISTRATION**
By registering, you will be able to take part in a tournament and will be able to purchase the *FIRST* LEGO League Field Set-up Kit. The team registration process will differ from country to country as does the cost. Select your country on www.*FIRST*LEGOLeague.org, visit the national website or contact the national organiser for details.

***FIRST* LEGO LEAGUE FIELD SET-UP KIT**
The Field Set-up Kit is the practice field for the Robot Game. The Kit changes each year and is usually ordered at the same time as you register your team. More teams may share the same Field Set-up Kit. The Kit consists of:
- A roll-out mat
- LEGO elements to build the "missions" for the Robot Game
- Some 3M adhesive squares to attach the mission models to the mat.

You may find it helpful to get hold of a table to support the mat. When you compete in the tournaments, tables will be provided at the venue. You can find instructions as to how you can build a table at http://*FIRST*LEGOLeague.org/challenge/teamresources#preparation.

**LEGO MINDSTORMS EDUCATION ROBOT SET**
Each team needs a LEGO MINDSTORMS set. You can use the RCX®, NXT® or the EV3 versions. This set will contain all the LEGO elements needed to construct a robot, a programmable brick, sensors, motors, and the software you need to programme it.

You can find a list of dealers who sell LEGO MINDSTORMS Education sets in your country at http://education.lego.com/en-us/distributors. In many of these countries, LEGO Education dealers or *FIRST* LEGO League partners offer training. Contact your nearest one for details.

> *"FLL is a challenge from start to finish. It is modern enquiry-based learning where co-operation across competences, gender, ages, and interests is at the core."*

# Sample time schedule

Below you will find a sample timeline for your work with *FIRST*® LEGO® League. Tournaments occur at different times of the year in the various FLL® countries, so check dates with your local Operational Partner and work out your schedule backwards from there.

We recommend that your students get acquainted with the LEGO® MINDSTORMS® robot set ahead of the FLL project period in order to be more prepared for solving the Robot Game and Robot Design tasks.

| | ACTIVITY | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEP W1 | SEP W2 | SEP W3 | SEP W4 | OCT W1 | OCT W2 | OCT W3 | OCT W4 | NOV W1 | NOV W2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-season** | Make sponsor strategy if FLL project is not part of school budget | ■ | | | | | | | | | | | | | | | |
| | Inform students - and possibly parents - about the FLL project | | | ■ | | | | | | | | | | | | | |
| | Brainstorm and choose a team name | | | ■ | | | | | | | | | | | | | |
| | Team registration | | ■ | ■ | | | | | | | | | | | | | |
| | Order LEGO® MINDSTORMS® robot kit and Challenge material | | ■ | ■ | | | | | | | | | | | | | |
| | Build FLL project into semester lesson plan | | | ■ | | | | | | | | | | | | | |
| | Get acquainted with the FLL Coaches' Handbook | | | ■ | ■ | | | | | | | | | | | | |
| | Let students get acquainted with the LEGO MINDSTORMS robot kit | | | | ■ | | | | | | | | | | | | |
| | FLL Challenge release | | | | | | ■ | | | | | | | | | | |
| **In-season general** | Review the Challenge documents (Robot Game and Project) | | | | | | | ■ | | | | | | | | | |
| | Make a season calendar | | | | | | | ■ | | | | | | | | | |
| | Determine team member roles and responsibilities (can change over time) | | | | | | | | ■ | | | | | | | | |
| | Reassess/revise season calendar based on progress | | | | | | | | | | | ■ | | ■ | | | |
| | Prepare judging and pit presentations | | | | | | | | | | | | ■ | ■ | | | |
| | Possibly contact local media to get media coverage for your team | | | | | | | | | | | | | ■ | | | |
| | Practice and fine tune judging and pit presentations | | | | | | | | | | | | | ■ | | | |
| | Participate in regional tournament | | | | | | | | | | | | | | | ■ | |
| **In-season Robot Design** | Build robot table (possibly volunteer parent) | | | | | | ■ | ■ | | | | | | | | | |
| | Build the mission models for the robot table | | | | | | | | ■ | ■ | | | | | | | |
| | Brainstorm robot game strategy | | | | | | | | | ■ | ■ | | | | | | |
| | Experiment with different robot designs and programming tasks | | | | | | | | | | ■ | ■ | ■ | | | | |
| | Assess/revise robot game strategy | | | | | | | | | | | | ■ | ■ | | | |
| | Make adjustments to robot design and programming | | | | | | | | | | | | | ■ | ■ | | |
| | Hold timed practice matches | | | | | | | | | | | | | | ■ | | |
| **In-season Project** | Brainstorm sources to research, Project ideas etc. | | | | | | | | | ■ | ■ | | | | | | |
| | Do research, collect data etc. | | | | | | | | | | ■ | ■ | | | | | |
| | Select a specific problem to focus on | | | | | | | | | | | ■ | ■ | | | | |
| | Brainstorm innovative solutions | | | | | | | | | | | | ■ | ■ | | | |
| | Choose how to present the Project | | | | | | | | | | | | | ■ | ■ | | |
| | Make presentation | | | | | | | | | | | | | | ■ | ■ | |
| | Share your Project with others | | | | | | | | | | | | | | | ■ | |
| **Post season** | Share impressions and lessons learned from the regional tournament | | | | | | | | | | | | | | | | ■ |
| | Thank sponsors and supporters | | | | | | | | | | | | | | | | ■ |
| | Possibly contact local media to get post-season media coverage for your team | | | | | | | | | | | | | | | | ■ |

# Tournament day

Tournament day is filled with excitement, nervousness and, above all, fun. The day also showcases something that we like to call 'Coopertition®'. This combines cooperation with competition and summarises the ethos of tournament days, where people from all over your country, or even the world, come together to tackle each Challenge.
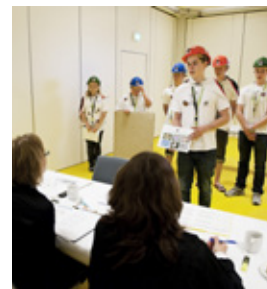
### ROBOT MATCHES
Your team will have at least three robot matches, lasting for 2 minutes and 30 seconds at the competition tables.



### PRESENTATIONS
Each team appears in front of panels of judges.
There are three things that they will need to present:
• The Project
• The Robot Design
• How they used the Core Values during their work.



### THE PIT
All teams are allocated what is known as a 'Pit'. This will be their home for the day. They can set up a display here which showcases the robot, the Project and how they observed the Core Values. The Pit is also handy for working on the robot, greeting other teams and spectators, or relaxing between robot matches and judging sessions.



### AWARDS
After the team presentations and robot matches, the judges will meet to review all of the presentations they have seen and decide which teams merit an award. The criteria can be found at www.*FIRST*LEGOLeague.org/event/judging. There will be a closing ceremony at the end of the day. Everyone who took part gets a medal, and the awards are presented to the winning teams.
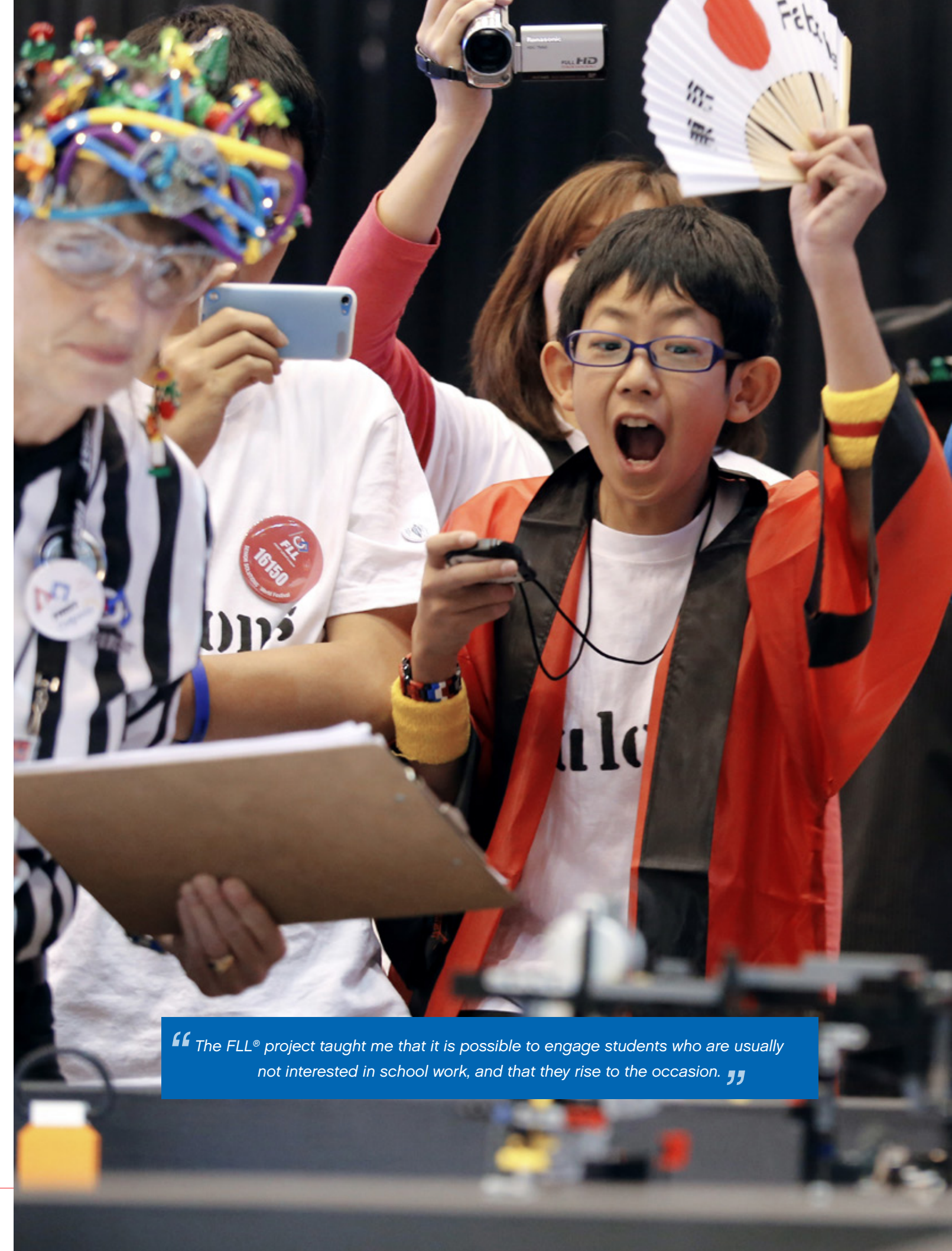
" *The FLL® project taught me that it is possible to engage students who are usually not interested in school work, and that they rise to the occasion.* "
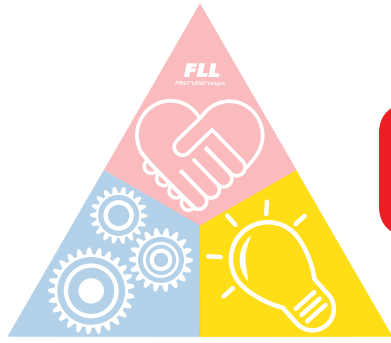
# Case Project presentation



## Team name: Team Fanatic

We are a school team made up of four girls and five boys. Our average age is 14 years.

### SOLUTION NAME: SMARTBAND

We had a presentation at school on welfare technology and that got us all thinking. When we were asked to develop a project that involved thinking about how technology can help people, we ended up exploring that topic and coming up with our own idea.

Senior citizens have lots of problems we can fix. People can forget where they are, have trouble climbing the stairs and even simple things like going to the shops can be a challenge. We spoke to some seniors, including Eric, who has mild dementia, high blood pressure and mild diabetes. And we also spoke to people who work in welfare and technology.

Our solution is a digital watch called the Smartband, and it helps seniors. We tried really hard to make it user-friendly and smart, so it can solve Eric's problems without him needing to really think about them too much.

It is based around an OLED screen. These are so thin that they can be printed. Importantly, it doesn't look like something clumsy attached to your arm. That's something we thought really carefully about.

### HOW THE SOLUTION WORKS

Here's how our Smartband works:
- It has a map with GPS, so that you can see where you are and care staff can find you if they need to
- It can measure blood pressure as well as pulse and sound an alarm if there's a warning
- The band can measure temperature and sweat
- A transmitter under the skin constantly measures blood sugar
- There is an alarm which tells wearers when to take medication
- The band is waterproof and has a flight safety mode
- There are date and time functions like a normal watch
- Home care services get an alert if there is an emergency
- You could have a built-in ID and medical card, so people in healthcare can scan it and all information pops up on a screen.

### OTHER INFORMATION

We felt that it should be voluntary to get a watch, not mandatory.

Its features could also be adjusted so that they meet the needs of the user, so that if there is someone with diabetes, it only displays their blood sugar level and so on. You could also have an app for relatives to download so that they can keep an eye on their family member, if they approve.

There is also an ethical dilemma here. Would we wear this ourselves? Our answer is that yes, we would. And we are happy that it can be worn as a piece of jewellery so that we don't need to think about wearing it. It just becomes an automatic thing to do.

### DISPLAYS AND PRESENTATIONS

We have written and sent two articles to our local paper. Since we came up with the idea, we have been in contact with a doctor and a district manager in elderly care. We have also spoken to a local innovation centre called the Growth Factory, Samsung and the Tryg Foundation.

We presented our project to parents and other FLL® teams. Everyone likes it and thinks it's really innovative, so we plan to go to an innovation fair later this year to get some more help with it.

Now we have two folders that show all our work on the Smartband and the ideas behind it that we can display in our pit when we compete in the tournament. A lot of effort went into decorating our pit, so we have two advertising pillars filled with pictures and explanations about the Smartband with pictures of people who cooperated with us in developing it.

As part of our teamwork exercises, we baked 300 cakes and decorated them with motifs intended to make people think about our work with seniors. We can give them out to anyone who wants to take part in our competition on tournament day, and maybe have some as snacks for ourselves.
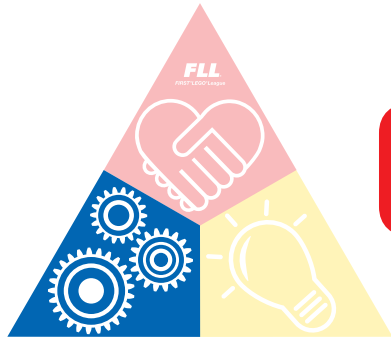
# Case Robot Design presentation

## Team name: Team Fanatic

Here is our robot design report.

The main influence on the design is that the robot needs to be as small as possible as there is not much space on the table. It also needs to be easy and quick to add and remove new tools. It only has two wheels to move it around the table, but there are two supporting legs. There are colour and touch sensors on each side of the robot so it can tell where it is and where to drive. We activate this by pressing the touch sensor.

### TOOLS

**Rubber band car:** this is a simple tool that hits the plate so that the 'dog' is pushed out of its position and can be grabbed using the pancake. It uses pneumatics and then four rubber bands for driving.

**Pancake:** this grabs the 'dog' and brings it back to base as well as positioning the blue and red plates. It uses a third motor that we can attach.

**Robot arm:** this uses a big arm to solve the 'medicine', 'stove' and 'ball game' missions. It also helps with both 'video call' missions, makes a rotation of the 'cardio machine' and picks up loops from the 'shelving'. We programmed the colour sensor using an algorithm.

**Woodwork:** this small tool goes out and gets the 'chair'. It operates without a motor and that gives us time to make a motor ready for the next tool. When the robot is performing this action, we move the 'chair' so that there is more room for the other tools.

**Last run:** this is the most advanced tool. It brings the 'chair' to the table and solves the 'bowling', 'gardening', 'transitions' and 'strength exercise' missions. We have a big folding arm which keeps the contact between the robot and the tools. First the small tool leaves the base, then the bigger tool follows. The small tool brings the 'chair' into position and then the big tool solves the 'strength exercise' and 'bowling' missions. As the last part of the task, the robot drives to the 'transitions' area which ends the match.
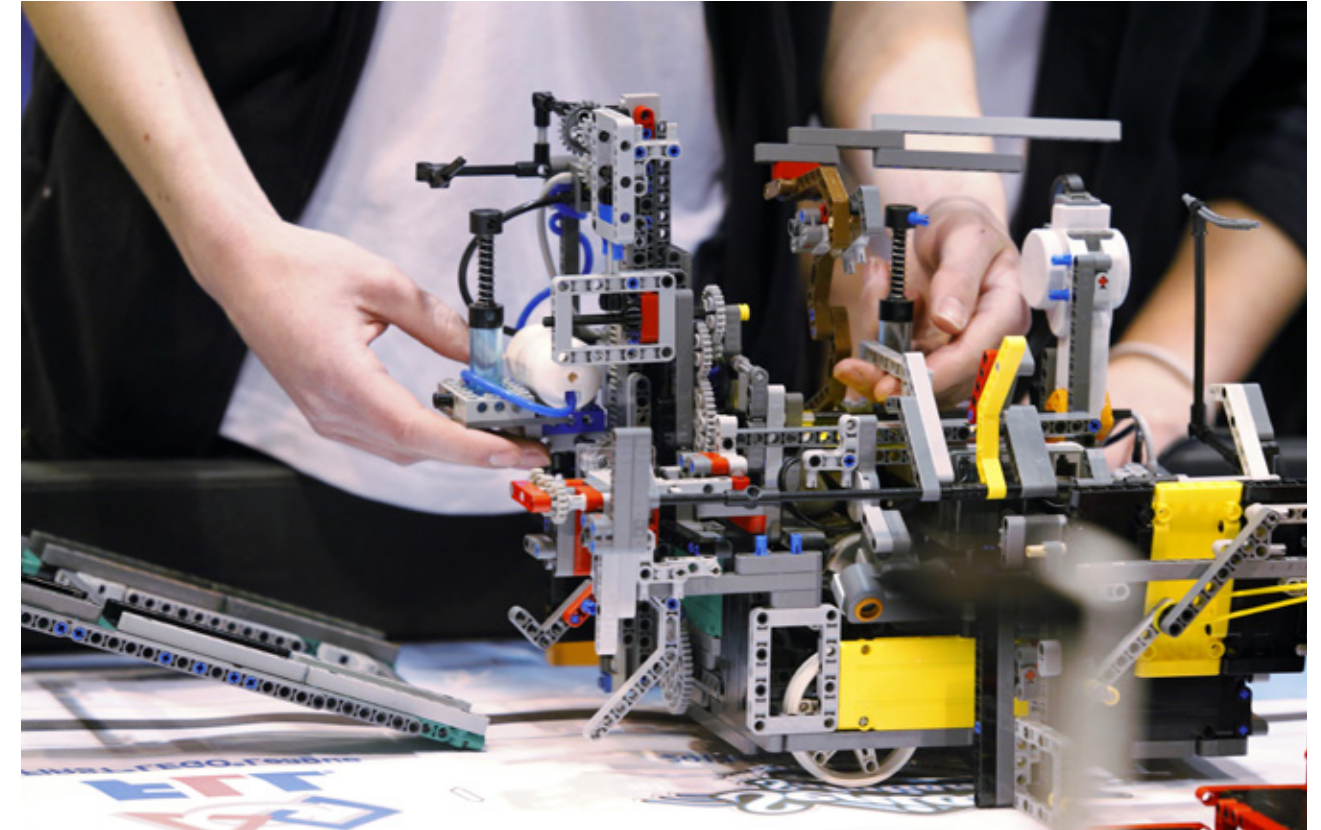
### PROGRAMMING

All the programming blocks are gathered into one, big system, so that they run as fast as possible. Our robot has a colour sensor which can read which tool is attached. This is possible because we have a big algorithm which runs when we press a touch sensor. On the robot arm, there is another colour sensor which detects the right 'medicine'. The program makes use of an algorithm which runs until it detects the green colour. The rest of the programming consists of simple drive blocks.
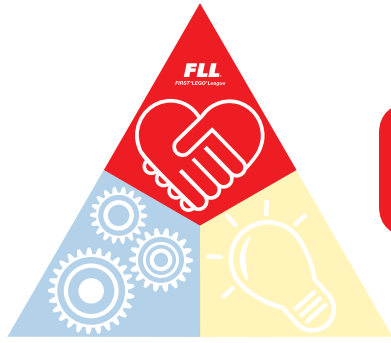
# Case Core Values presentation

## Team name: Team Fanatic

### INTRODUCTION

We had a good experience working with *FIRST*® LEGO® League in previous years and that's why we decided to do it again. Our coach divided us up and made sure we had a mixture of experience in each team, so we had a blend of FLL® veterans and rookies.

### HOW WE OBSERVED THE CORE VALUES

The most important thing was that we set ourselves objectives at each stage so we knew if we were successful. We made sure that we always evaluated what we were doing and all had an input into each stage, like programming, building the robot and research.

As we're an optional class team, we had an age span that went across three grades. It was really important to make sure that the younger members still felt like they had a say. If we had a good idea, we made sure to share it, so we all had a clear idea of possibilities and challenges.

Because some of our team members are rookies, we had to make sure they were introduced to FLL and knew lots about it. In the end, they contributed just as much as the veterans and we came together well as a team. So no one was left to work on anything by themselves .

The team was built on cooperation. Everyone had the chance to help and we always made sure people who knew more about a subject could contribute. If you knew you had a weakness, we all really believed that, together, we could help turn it into a strength. It's also more exciting and fun if you work together.

Seniors and experts have also been supportive and we made sure that we always discussed what they had to say. We also helped another team in our school, called Future Minds, as they are younger and less experienced. We thought they could benefit from our help.

The final thing is that we benefited from talking to our friendship team in the US. We got to learn how they planned to solve the same problems that we were working on and we helped them, too.

FLL

FIRST® LEGO® League

For more information about FIRST® LEGO® League
www.FIRSTLEGOLeague.org