Instructors' Manual

Geared Up: an After-School Robotics Program |By Haley Hanson

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Introduction

Foreword

I have over 8 years of experience in the field of robotics, both in the hands-on experience of competing on various robotics teams and through mentoring 50+ teams/groups over time. Through mentoring and setting up this program at schools, I have worked with guiding many people of differing ages and abilities towards a practical solution to complex situations.

I have created this Instructors' Manual to pass along my knowledge and make starting a robotics team/group a pain-free process.

Before You Start

It's a good idea to go through and personally experience each step before teaching the students that section, it's informative and fun. See the 'Instructors:' segment (*where applicable)* of each 'Detailed Curriculum' section for more guidance on this topic.

This manual is a **guide**; which means it should be used and modified it to best suit each situation. Take the time to find the best fit for your school/group and move at a pace that is beneficial for the individuals. Keep in mind, everyone is learning a lot of new material. The level of comfort and amount of previous knowledge will be a huge indicator of how long each section should last. Some sections will, and should, take longer than others.

**If you are not sure at which pace you should be moving, would like help tailoring the program to your school/groups individual needs and circumstances, or have any comments or questions please email gearedupforrobotics@gmail.com

Program Overview*

3-4 Meetings	
	Mission Model Build
	-Students familiarize themselves with LEGOs and get comfortable working with them. This lays the foundation for building the robot and its attachments later on.
1-2 Meetings	
	"Be the Robot" Activity
	-An obstacle that allows the students to "wear the shoes" of the robot
2-3 Meetings	
	Sensor Exploration
	-Students explore the robot's 6 different senses (5 if using the NXT) and the motors
3-4 Meetings	
	NXT-G/EV3 Tutorials
	-Students get their first taste of programming, use the finished programs to create their own missions "Backwards engineering"
1-2 Meetings	
	Testing Tutorials
	-Students test the tutorials on pre-made tribots
1-2 Meetings	
	Mat Reveal
	-For the first time the mat that they will be using is revealed, students will begin strategizing their missions using a LEGO vehicle
4-5 Meetings	
	Robot Build
	-Using the instruction booklets printed for them, students can build their tribots
3-4 Meetings**	
	Program Missions
	-Students solve the challenges using their tribot, original program code, and unique attachments they build
18-26 Meetings Total (approximately)	

*Based on 3, 1 ½ hour, sessions per week. Adapt timeline as needed.

**This part can be as long or as short as you want, this is where the kids are 'competition-ready' so challenge them and give time to succeed.

Proposed Timeline

May-September
FLL Registration is open. Register Team.
NOTE: You do not need to participate in any tournament. This is an optional, recommended, step. Registering gives you access to the mat and field kit that will be used as well as a discounted price on the robot kit. Should you choose to participate in your local tournament, please review the "CORE Values" on page 20.
September
New challenge is released
Order Field Kit and Mat.
-You can do this at the very beginning of the program and do the "Be the Robot" Game until the materials arrive; or, the more suggested route, order as soon as possible since registration closes once field kits and mats run out.
September
Start Program
Begin "Be the Robot" game
-Depending on whether you have the materials yet or not
Build Mission Models
Sensor Exploration
NXT-G or EV3 Programming Tutorials
October
Testing Tutorials
Mat Reveal and Strategize
Tribot Build
November
Program Missions
~January
FLL Competition
-I highly recommend attending an FLL competition to see the other solutions to the challenges that children came up with and experience the excitement and fun. Even if you do not compete, view one of your local FLL competitions. Dates vary from region to region; visit **http://www.usfirst.org/whats-going-on** for the nearest event to you.

Itemized Materials List

Qty	***Item***	***Cost***	***Purpose***	***Place of Purchase***
1	Team Registration (Optional)	225.00	Gaining access to the mat and field elements, as well as a discounted Ev3	https://gofll.usfirst.org/users/new Create new account. Click on 'Register New Team'
1	Field Setup Kit	75.00	Provides the Mat and Mission Models needed to strategize and program the robot for	https://gofll.usfirst.org/material_orders
1	Robot Game Table	100.00	A 4x8ft table used to hold the mat the robot drives on	Purchase material (Home Depot), print out instructions and assemble or email GearedUpForRobotics@gmail.com for a table
1*	FLL EV3 Robot Set	499.00	Supplies the Robot brain, parts, software, and tutorials	https://gofll.usfirst.org/material_orders
1*	FLL NXT Robot Set	435.00	Supplies the Robot brain, parts, software, and tutorials	https://gofll.usfirst.org/material_orders
1	Safety Flag Tape	19.02	Used to rope off the "Be the Robot" course (1000ft)	Home Depot (Can also use Caution Tape)
1	Scarf (OPTIONAL)	1.00	To be used as a blindfold in "Be the Robot"	Dollar Tree, any closet, or a bandana
1	Set of four resource binders (Print Own Set)	50.00~	Includes full color 'Building Guide', 'Programming Guide', 'Mission/Rule Guide', and 'Instructors' Manual'	APS Graphics, (or other school district's teacher's store), et cetera... Print out .pdfs http://gearedupforrobotics.weebly.com/resources.html
Total Cost w/EV3: Total Cost w/NXT		$969.02^ $905.02^		

^Initial start up cost of the program, with a recurring cost of $350 for an FLL team (optional)

*One Robot Kit for every 3-5 students. I recommend having an "extra" one for the teachers.

Materials Checklist

- **Team Registration
- Safety Flag or Caution Tape
- Blindfold or Scarf
- Building Guide
- Programming Guide
- Challenge Guide
- Field Setup Kit
- Robot Game Table
- NXT or EV3 Brain
- Resource Kit (For NXT or EV3)
- NXT-G or EV3 Software
- *Pre-Constructed LEGO vehicle
- *Premade LEGO Tribot (for tutorial testing)
- **Spare LEGOs (to build robot attachments out of)
- Element Overview
- Table Items (the tracking sheet)
- Scoring Sheet
- Pre-challenge Strategizing Sheet
- Field Worksheet
- Pencils, pens, and/or dry erase markers
- Computers (Mac or Windows)
- Mat Printout (to be used for strategizing)
- **LEGO Digital Designer (Free Download)

*These can either be made by the instructors (recommended) or the students at the beginning of the program during the mission model build. I recommend the instructors build the tribot so that they can experience building the tribot and better help the students' struggles when they encounter the problems, it also keeps the robot a surprise until later on and prevents distraction.

**Optional

Outside Resources

ldd.LEGO.com (LEGO Digital Designer Site)

www.techbrick.com

gearedupforrobotics.weebly.com

www.legoeducation.us

Robotics Competitions

www.usfirst.org

roboquerque.org

www.botball.org

NXT VS EV3

	NXT	EV3
History	Introduced in 2006. Second generation of LEGO®MINDSTORMS® Education.	Introduced in 2013. Third generation of LEGO MINDSTORMS Education.
Building System	LEGO Technic	LEGO Technic
Software	**(NXT-G)** Graphical and icon based. Powered by National Instruments LabVIEW™.	**(EV3 Software)** Graphical and icon based. Powered by National Instruments LabVIEW™..
Hardware	Intelligent brick, five sensors, three motors, hundreds of parts.	Intelligent brick, five sensors, three motors, hundreds of parts.
Support	One-year warranty. Tech support for the life of the product.	One-year warranty. Tech support for the life of the product.
Availability	Now, and sold until the end of 2015.	Sold "indefinitely".
Cost per student over 5 years average use	Under $18	Under $20
***FIRST* LEGO League**	Allowed and supported	Allowed and supported
RoboRAVE	Allowed and supported	Allowed and supported
TETRIX	Supported	Supported
ROBOTC	Supported	Supported
LabVIEW for LEGO MINDSTORMS	Supported	Supported

Program

Detailed Curriculum

3-4 Meetings

Mission Model Build

Description: Students build the mission models they will be using later.
Purpose: Students familiarize themselves with LEGOs and get comfortable with building. This lays a foundation for building that they will use in the future when building the robot and inventing their own attachments. This also gives a peek into what the missions will be if they choose to read the backs.
Materials:

- **Field Kit**
- **Instruction Booklets**
- **Projector**

Steps:

1. **Download the "Mission Model" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Print out the mission model build instructions**
3. **(Optional) Print the mission/s corresponding to that model and stick the short description on the back cover, very useful later {Pictured below}**
4. **Laminate the covers to make them reusable**
5. **Take each model's instructions and put them in their own book**

6. **Go over the brief slide with the students**
7. **Have students group up in teams of two**
8. **Let children choose the models they want to build and begin!**

Detailed Curriculum

1-2 Meetings

"Be the Robot" Activity

Description: An obstacle that students navigate as the robot with a programmer instructing them

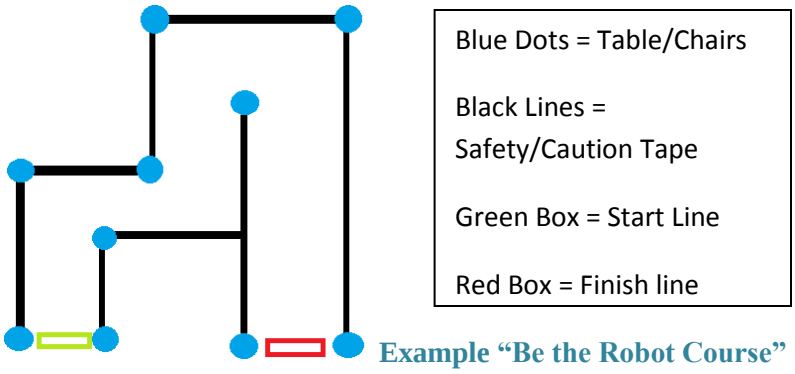
Purpose: To have the children step into the shoes of the robot. They form an understanding (without yet realizing it) that the robot has no senses until they add them and that it cannot think for itself, it must listen to what the programmer says and do only that

Materials:

- **A few blindfolds or scarves**
- **Safety flag or caution tape**
- **Projector**

Steps:

1. **Download "Be the Robot" Slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **~15mins before the students arrive, start setting up**
3. **Take the Safety/Caution tape and start roping off a course with 45° turns**
4. **Go through the slide with everyone and make sure they understand**
5. **Ask for a volunteer "Programmer" and "Robot" and repeat until everyone has had a turn in each role**
6. **(Optional) Take volunteers to redesign the obstacle course. Make sure it is possible and safe to complete after they finish with their designs**



Example "Be the Robot Course"

Detailed Curriculum

2-3 Meetings

Sensor Exploration

Description: Students explore the robot's 6 different senses (5 if using the NXT) and motors
Purpose: For students to understand the similarities and differences between the robot's senses and theirs, and to know what the robot has available
Materials:

- **Robot Kit (W/Brain and Sensors)**
- **Projector**

Steps:

1. **Download "Sensor Exploration" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Set it up so that each sensor category has a different table; or, if you have enough instructors, have each sensor at its own table**
3. **Put an instructor to man each station (Make sure they understand what the use of each sensor is, what type of data it gathers, and how it can be used)**
4. **Go over the slide with the group**
5. **Have groups of ~3 students each cycle through the stations**

Sensor Name	Human sense it relates to	Function	Type of Data it collects
Light Sensor	Sight (Part 1)	Detects how light/dark something is (the light intensity)	1-100. Measures ambient or reflected light
Color Sensor	Sight (Part 2)	Differentiates 8 colors	Same things as light sensor AND can identify the colors blue, green, yellow, red, white, and brown AND differentiate between other colors
Ultrasonic Sensor	Sight (Part 3)	Measures distances	~1-48cm, or ~1-24in
Sound Sensor	Hearing	Detects volume	Decibels
Touch Sensor	Feeling	Can tell when it's "hit" something. Detects when it is pushed in	0,1 (Off, On) (Released, Pressed) There is also "bump" which means it was 0, 1, then 0 again
Gyro Sensor	Balance	Gives the robot stability	Degrees of rotational motion (+/- 3°) Maximum of 440°/sec
Motors	Movement	The robot's "legs" programmable to move specified distances	Either degrees or rotations (Of the motor, not the wheel; so, if there is a larger wheel on there, it will take more than 1 rotation to have the wheel move all the way around)

Detailed Curriculum

3-4 Meetings

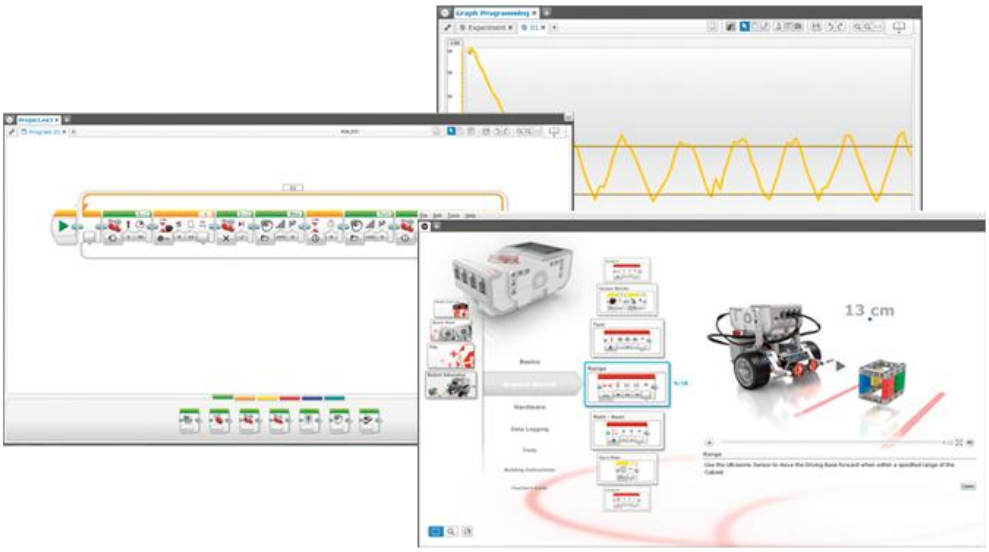
NXT-G/EV3 Tutorials

Description: Students get their first taste of programming with a computer. The language will depend on which brain (NXT or EV3) was chosen, but both will be graphical and come with programming guides and step-by-step programming tutorials.
Purpose: To teach students the basics of programming and prepare them for programming on their own come "Mission Day".
Materials:

- **NXT-G *OR* EV3 Programming Software**
- **Computer**
- **Projector**

Steps:

1. **Download the "Programming Tutorials" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Make sure all of the computers have the software installed and are ready to run**
3. **Go over the slide with the group**
4. **Have students either split off into groups of 2-3 and trade off after each step or work individually (up to you)**
5. **Set up an Instructor to do the "follow through" slide (at the end of the power point) to guide students through the first tutorial (Skip the last step of 'downloading' until the "tutorial testing")**
6. **Have each student watch the slideshow or video of what the robot is supposed to do before coding. This is found in the tutorial and is the largest window of the options**
7. **In NXT-G, make sure the students learn at least the following tutorials: "Turn", "Parking Bay", and "Follow Line"**



Detailed Curriculum

1-2 Meetings

Testing Tutorials

Description: Students test the tutorials on pre-made tribots as well as also given the opportunity to create their own missions for the robot to complete based on its current actions.

Purpose: Testing the programs is to showcase the students' talent in programming and see their hard work pay off. The creating of their own missions teaches them backwards engineering and will allow for more of a connection to form between programming and making the robot complete valuable tasks.

Materials:

- **The programs the students created**
- **The Tri-bot**
- **Computer**
- **(Optional) Projector**

Steps:

1. **Download the "Tutorial Testing" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **(Optional) Go over the short slide with the group**
3. **Make sure everyone remembers what they named their programs**
4. **Download the programs onto the testing Tri-Bot**
5. **Run each program and have the students observe the pattern**
6. **Tell them to create their own "mission, a task for the robot to complete, with its current movements (choosing from the tutorials they programmed)**
7. **Set up and run each student's mission**

Detailed Curriculum

2 Meetings

Mat Reveal

Description: The mat they will be using, be it a simple line mat or one covered in graphics, is revealed to the students. In addition to examining it, they will take a Lego Vehicle or just their hands and navigate through the course practicing strategies and mapping out potential routes for the robot to take. This is also the day the missions are revealed and each one chosen by the kids is read out and strategized in theory. Make sure to have printouts of the field for them to draw on to show their route.

Purpose: To introduce students to strategy and familiarize them with the course their robot will be working on.

Materials:

- **Field Mat**
- **Printouts of the field, a laminated one for them to write on with dry erase, and/or just a paint file open that they can draw on**
- **Markers**
- **Lego Vehicle**
- **Mission booklets (or just the missions printed out to read)**
- **Mission Models**
- **Picture of the proper field setup**
- **(Optional) DualLock to adhere the mission models to the mat**
- **(Optional) Projector**

Steps:

1. **Download the "Mat Reveal" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Set up the mat and mission models according to the proper field setup**
3. **(Optional) Go over the slide with the group (This is a very short one)**
4. **Tell each student to pick out a mission that looks fun to them, if multiple people pick the same one that is okay, just inform them they will be working together on that one (up to groups of 3)**
5. **Have them read their mission aloud to the group then each demonstrate it with the Lego vehicle**
6. **Once everyone knows the missions, have each student draw out the path they think the root should take for their mission and write down the actions it needs to do (ex. Go forward, turn left, raise arm, lower arm, turn right, go backwards)**
7. **Save everyone's strategy for "Program Missions" day**

Detailed Curriculum

4-5 Meetings

Robot Build

Description: Students finally build their own tribot! The moment many have been waiting for has finally come, but it was important to save this for the end so the robot wasn't distracting students. Using the instruction booklet that comes with the Lego Mindstorm kit, students will build their first robot. Students will also learn the basics of the robot's brain.

Purpose: To improve the building skills of the students and to familiarize them with the brain of the robot, as well as have a robot to program to complete the missions.

Materials:

- **Lego Mindstorm kit (NXT or EV3)**
- **Projector**

Steps:

1. **Download the "Robot Build" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Have students divide into groups of 2-3**
3. **Go over the slide with the group**
4. **Guide students through the instruction book as necessary**

Detailed Curriculum

3-4 Meetings

Program Missions

Description: The final step! Students program their built robots using the strategies they came up with in "Mat Reveal". But that's not all, students will also have to edit their robot base to complete certain missions. Whether this means adding an arm or changing the base, it's bound to be necessary and it's a good thing the students know how to build know. They will also have to change and modify their strategy and program the missions from scratch.

Purpose: To truly test and showcase the skills of the students with a challenge suiting for their experience.

Materials:

- **Tribots**
- **Computer**
- **Lego Mindstorm Kits**
- **Mat**
- **Mission Models**
- **Extra Legos**
- **Strategizing tools**

Steps:

1. **Download the "Complete Missions" slide from http://gearedupforrobotics.weebly.com/resources.html**
2. **Go over the slide with the group**
3. **Have students gather into their "Mat Reveal" groups (1-3) for their first mission**
4. **Make yourself easily accessible to the students, this is their first time not having tutorials or instructions to follow, they might have a lot of questions**
5. **Encourage the students program and edit their robot to complete the missions according to their strategy**
6. **After everyone's first mission is complete, have them break up into groups of at least two so they're working with someone**
7. **Sit back and enjoy the job well done**

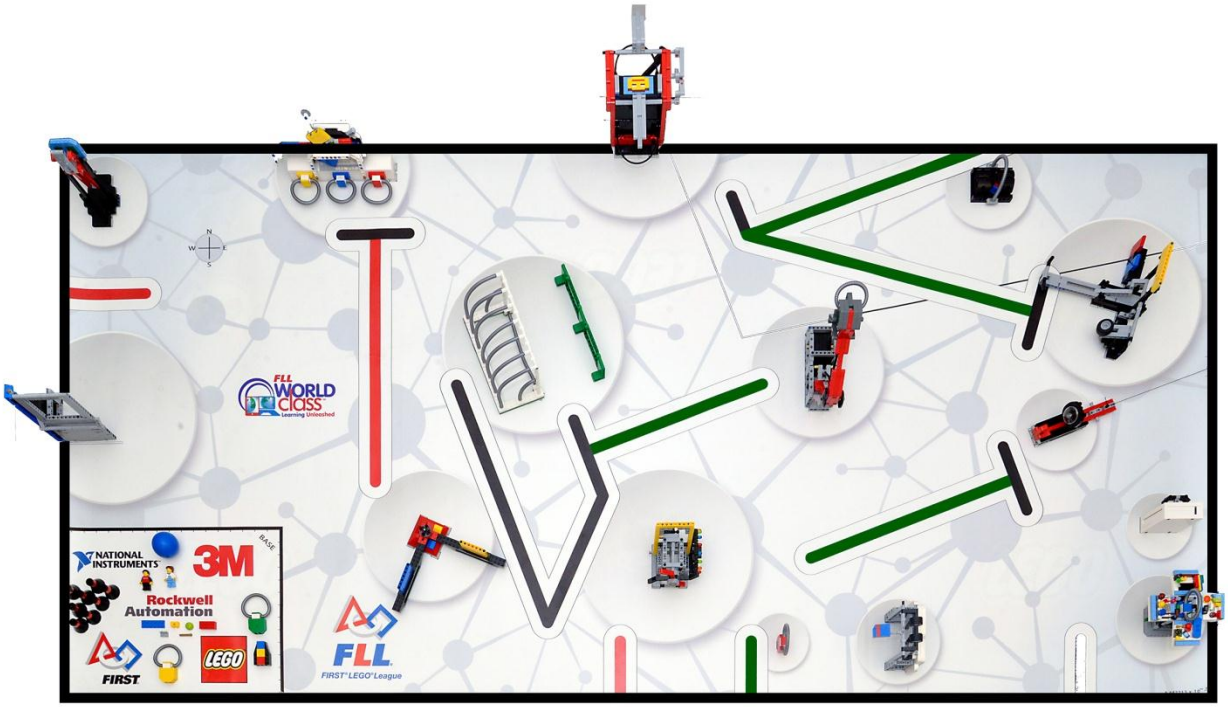
Building

The first experience building will happen in the first two weeks during the mission model build. Below are just a few examples of what the mission models might look like. Find the complete and current mission model build guides at http://www.firstlegoleague.org/missionmodelbuildinstructions

For table construction, check out page six of the challenge guide. (May vary from year to year, page six of 2013-2014 Nature's Fury Challenge Guide)

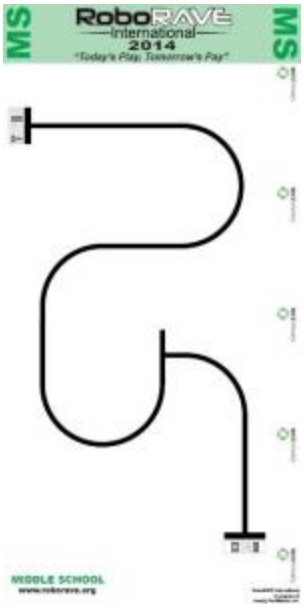
The Tribot instructions come inside of the robot kit; however, if you want another place to view the steps or enjoy digital walkthroughs, inside the tutorial section of NXT-G there is a directory called "Common Palette" open it. Pick any of the tutorials that have the robot drive, there will be a tab called "Building Guide" that will have step by step instructions of how to construct the robot.

Field Mat



Above is an example mat, as is used by FLL, the most recent FLL mats can be found on their website as listed in 'Outside Resources'

Below is an example of a RoboRAVE mat for Middle school, other mats can also be found on their website as listed in 'Outside Resources'



CORE Values

We are a team.

We do the work to find solutions with guidance from our coaches and mentors.

We know our coaches and mentors don't have all the answers; we learn together.

We honor the spirit of friendly competition.

What we discover is more important than what we win.

We share our experiences with others. We display Gracious Professionalism® and Coopertition® in everything we do.

We have FUN!

See more at: http://www.firstlegoleague.org

Coopertition (pronounced co-op-ertition) is the practice of helping everyone in a competition, especially your competitors. Robotics is a sport where we want to see innovation and success, we want to see **everyone** succeed and be gracious in acknowledging their success even when we ourselves do not succeed.

This set of 'CORE Values' is taken directly from the FIRST Lego League site and is what every team must abide by in competition. Competing or not, these are great words to have the kids understand and follow throughout the program, this can either be done through example, guidance towards these characters, and/or straight reading of the values.