Steps to starting a LEGO robotics program

Congratulations on your decision to start a robotics program! Whether you are a teacher, parent, coach, or an afterschool club leader, you’ll find lots of support as you move through this process.

Carnegie Mellon’s Robotics Academy has compiled a comprehensive step-by-step plan to help guide you through this process. All of these steps are relevant to teachers, parents, coaches and club leaders. Teachers will also need to decide on the educational specific outcomes that they are trying to achieve as well as how robotics aligns with their school district’s standards.

Step by step organizer:

1. Decide what it is that you want to teach and how robotics will be an effective organizer. e.g. are you using robots to reinforce and teach math concepts, programming, teamwork, problem solving, or are you preparing your students for competitions?

2. Select the hardware that you will use as well as the programming language that will be appropriate with the students that you teach.

Middle School – Robotics is the ideal organizer to reinforce fundamental mathematics and scientific process, it also allows the teacher to introduce the concepts of systems integration, digital control, and innovative design.

LEGO NXT is an ideal solution for middle school teaching; The LEGO Mindstorms Education Base Set will allow you to complete all of the lessons in both of the curriculums created by Carnegie Mellon – Robotics Engineering Vol. I - Introduction to Mobile Robotics and the Robotics Engineering Vol. II - Guided Research. If it is in your budget, we recommend purchasing at least one Education Resource Set with every two NXT Education Base Sets. This accessory kit includes many parts and connectors not included in the Education Base Set; including tracks.

NXT-G is the original programming language for the LEGO NXT robots and is appropriate for middle school. The two Carnegie Mellon developed curriculums are based on the NXT-G programming language.

Another option is ROBOTC which teaches students an industry standard “C” programming language and is compatible with other robotics platforms like VEX, the FRC controller, and other pic controller based hardware. Carnegie Mellon created the curriculum Teaching ROBOTC for LEGO Mindstorms to support teachers who choose this programming language.
**High School** – LEGO NXT is an excellent choice at the high school level. The NXT offers teachers an inexpensive tool to teach embedded systems, advanced programming, and engineering competencies. High school teachers have the option to include accessory kits and a whole array of third party sensors such as the compass sensor, accelerometer, tilt or gyro sensor, color sensor, and cameras.

Appropriate programming language options for the high school students include the NXT-G programming language, ROBOTC, LabVIEW and Java. The high school teacher may want to augment their course by using one or more of the competition models that can be found for free at this site, or enter their school into a robotics competition. There are many other platforms that a high school teacher may want to evaluate, but the LEGO NXT brick is a very powerful platform to use to introduce robotics.

3. **Research available curriculum and resources**

Go to the curriculum link at the Robotics Academy website to see examples of robotics curriculum that over 6,000 schools are using today.

4. **Decide on the size and number of student teams.**

   a. All work should be done in teams of 2 or 4 students per robot. Teamwork is a crucial skill in the modern workplace, and the challenges of the robotics activities lend themselves to group solutions.

   b. Odd numbers of students on a team can often lead to problems with one student being left out and not doing anything. Groups larger than 4 are generally too large for all the students to have something important to do.

   c. For classrooms, two students per robot is ideal; for clubs and teams, many coaches need to have a higher student to robot ratio based on resources.

   d. Some competitions, such as the FIRST LEGO League, limit team size to 10 students.

   e. First-time coaches typically do well with about 8 students. If possible, recruit other mentors to lead the subgroups within your team.

   f. Define roles on the team and have students change roles on a regular basis, allowing them to share responsibility for all aspects of building, programming, etc.

(1) Engineer (Builder)

(2) Software Specialist (Programmer)
(3) Information Specialist (Gets the necessary information for the team to move forward)

(4) Project Manager (Whip-cracker)

g. When participating in a competition that requires a research project, assign one team member as the lead.

h. For classrooms, unisex teams are preferable; research has found that boys use an autocratic decision making process excluding girls from participating in many of the technical lead roles. For clubs and teams, unisex pairings are recommended, when possible.

5. Identify technical and logistical requirements

a. Robots – Robotics Academy recommends one robot for each team of 2 students. Also, the teacher should have several backup robots in case of emergency situations.

b. Computers - Ideally, there should be one computer for each robot / team of students. Most of the students’ activity will be independent and self-directed as they iteratively program / test / debug their solutions multiple times during each practice. Multiple computers will provide easy access to the programming language, eliminate “traffic jams” and inadvertently changing another team’s program.

c. Classroom / Practice area

(1) Room size and setup – The space should be large enough to accommodate all the student teams, computers, practice tables, projector for lessons, and storage area for the robots.

(2) Practice table – Required to avoid damage to robots and keep activities accessible to all students. At a minimum, the table should have borders to prevent robots from falling off. The FIRST LEGO League challenge table specifications will accommodate a 4x8 foot surface.

(3) Parts storage – To keep parts organized and accessible for teams, parts organizers are necessary. There are many options – portable organizers, drawer cabinets, boxes, caddies, etc. These are readily available online and at local hardware and crafts stores.

d. Network - The software and curriculum will need to be loaded on each computer or available via the network on each computer. Programs should be included in the regular system backup or leader should make a backup to a separate disk or memory stick.
e. Projector – Teachers will find it valuable to review videos, building instructions, etc. with the entire class.

6. Prepare a budget and get funding

a. Typical classroom budget – will consist of robots, programming language, curriculum, materials, competition fees, etc. The final cost for your robotics program will depend on the size of your team, activities, etc. Here are typical costs to use when calculating your budget:

1) Robots - Robotics Academy recommends one robot for every two students.

   $260 for each LEGO MINDSTORMS Education Base Set

   $69.00 for each Education Resource Set; one for every two robots

2) Programming Software Classroom license

   (a) LEGO NXT-G $295

   or

   (b) ROBOTC for LEGO MindStorms $225

3) Curriculum Classroom license

   For LEGO NXT-G:

   (a) Robotics Engineering Vol. I $225 for a classroom license

   (b) Robotics Engineering Vol. II $225 for a classroom license

   For ROBOTC

   (c) Teaching ROBOTC for LEGO $225 for a classroom license

4) Storage bins/cabinets

   This is a must have for any teacher implementing a LEGO robotics program. Your budget will be dependent upon the selection of the cabinet and bin combination that you choose. The proper storage compartments as well as classroom procedures will make teaching robotics much easier.

5) Practice Table ($100) and white insert board for competitions ($12.00 each)

5) Optional – Competition registration fees, team shirts, supplies, end-of-season
party and awards, etc. ($300.00)

b. Potential sources of funding – Be sure to acknowledge your sponsors at every opportunity, e.g. print their names on your team shirts, etc.

(1) School district

(2) Local businesses

(3) Local non-profit organizations

7. Connect with the robotics educators community locally and virtually

a) Find another robotics team in your area and ask to attend their practice sessions. This is very helpful for first-time coaches.

b) Robotics Academy

c) Robotics Educators Conference

8. Attend teacher training

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Recap of the major steps to implement a robotics program:

1. Purchase robot kits

2. Purchase robotics curriculum

3. Load software and curriculum on your computer and school network

4. Build practice table (optional)

5. Schedule training – this can be self paced by enrolling in the free online training, or you can attend formal training.
6. Practice building and programming your robot

7. Recruit older students as mentors/assistants

8. Prepare lesson plans – comprehensive lesson plans are included in the Carnegie Mellon curriculum, examples can be found at NXTeacher.com

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**For each lesson:**

1. Teacher Preparation
   
a) Identify scope and choose sequence of robotics activities

b) Read through curriculum Teacher Notes for each activity

c) Understand the student steps for each activity

2. Lesson
   
a) Introduce lesson, optionally using the supplied Lesson Starter PPT presentation in curriculum

b) Direct students to the appropriate starting point at the beginning of the lesson, and let them begin.

3. End of Lesson
   
a) Collect worksheets to correct

b) Hold final discussion to answer any student questions

c) Administer Quiz

d) Move on to next lesson
4. End of Class (each period)

   a) Put the robots somewhere safe for next time the class will meet. Or - return the robots to their original state (remove attachments; undo any changes you made to the gears, wheels, etc.)

   b) Clean up loose LEGO parts (use the sorting trays and maps)

   c) SAVE ALL PROGRAMS

   d) Assign homework questions

5. End of Project

   a) Select one or more End of Project Activities

   b) Schedule milestone dates – outlines, drafts, final presentation/competition, etc. depending on the specific activity chosen

   c) Assign the selected activity at least 2-3 weeks before it is due

   d) Prepare classroom or venue for final presentation or competition if applicable

   e) Hold final presentation/competition