Introduction to
NXT/EV3 Robotics

STOMP Curriculum
September 2014
Notes

Description
This unit serves as an introduction to NXT/EV3 Robotics with opportunities for the students to both build and program. It is a unit of 9 lessons, each about 60 minutes long. It is designed for grades 4-6 but can be adapted for different students or a different time frame.

The purpose of this unit is to broaden students’ understanding of the applications of robotics. It is meant to provide examples of creative NXT/EV3 activities to introduce the basics of robotics in an accessible, fun way.

To teach this unit, you will need NXT/EV3 robotics kits (about 1 for every 2 students) and computers or laptops with the correct Mindstorms software (about 1 for every 2 students). In the curriculum below these materials are simply referred to as “NXT Robotics materials.”

In Practice
Before going into the classroom, thoroughly familiarize yourself with the LEGO NXT/EV3 and Mindstorms technology. Resources are available through the STOMP website and the Center for Engineering Education and Outreach. Build and program yourself! Be sure you have done all of the activities before going into the classroom. It will help you to predict what will be challenging for the students. This curriculum will NOT teach YOU how to use the technology—it assumes you have those skills already.

This unit covers a lot of material, so think carefully about what you want your students to spend time on. For example, if a student is struggling to figure out how to connect two beams, you may show him/her how to insert two pegs to make a sturdy connection. On the other hand, if a student is struggling with the design, do not give him/her your design idea. Instead, treat this as a valuable learning moment and ask guiding questions to lead him/her to a feasible conclusion. A good strategy is to rephrase the students’ ideas, like “I think you are trying to… is that right?”

Questions for STOMPers to Think About
You may want to consider the following questions over the course of the semester: What do you want to see your students doing in this unit? What do you hope your students will learn? How will you measure your students’ progression? How can you make the activities relevant to the real world? What interpersonal skills do you want them to practice?

Questions for Students to Think About
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Lesson 1: Wheelchair Design

Overview: This lesson introduces the students to engineering, the engineering design process and robotics. Then, the students use the LEGO NXT kits to build a wheelchair.

Learning Goals:
1. Students will identify examples of robotics in their daily lives.
2. Students will practice the planning stage of the engineering design process.
3. Students will familiarize themselves with the pieces from the LEGO NXT kits

Materials:
• LEGO NXT kits (1 for every 2-3 students) (Students use only the top orange bin)
• Stuffed bears (found in supply closet, 1 bear per group)

Lesson Plan:
1. Introduction (15 minutes)
   o Introduce yourselves, and ask the class some questions to get started. Eg: What do engineers do?
   o Before giving the students their first project or the NXT kits, establish a set of ground rules or classroom norms (see References).
   o Describe the engineering design process (EDP). It is helpful to use the whiteboard or a poster so that you can refer back to it throughout the day. Emphasize that engineers NEVER get things right the first time, they have to try again! All engineers fail.

2. Main Activity (40 minutes)
   o Have the students brainstorm criteria. What makes a “good” wheelchair? Take notes on the board.
   o Their challenge is to design a non-motorized wheelchair that meets their design criteria.
   o Divide the students up in to groups and distribute the LEGO NXT kits. Have the students begin to build their wheelchair.

3. Wrap-Up (5 minutes)
   o Clean up! Label the students’ projects/NXT kits and collect the wheelchair assignment sheets to redistribute next week.
   o Review the EDP. Ask the class which steps they will be doing next week (building and testing).
   o Make sure that you take note of the design criteria so that you can write them up on the board next class.

Modifications:
• Silly Walks is also a great introductory activity to building with the NXT/EV3.
Lesson 2: Wheelchair Testing & Redesign

Overview: Students will continue the wheelchair project from last week.

Learning Goals:
1. Students will practice building with the pieces from the LEGO NXT kits.
2. Students will practice testing and redesigning their LEGO wheelchairs.

Materials:
• LEGO NXT kits (1 per 2-3 students)
• the wheelchair assignment sheets from last week
• stuffed bears

Lesson Plan:
1. **Warm-Up** (5 minutes)
   - Have the students recap last class by asking them to think about the EDP. What steps did the students do last week? What steps will they be focusing on this week? Building, testing, and redesign.
   - Review the important LEGO NXT pieces. If you noticed your students struggled with one aspect of building last week, give them tips to overcome that.

2. **Main Activity** (45 minutes)
   - Redistribute the assignment sheets and NXT kits. Give the students some time to finish their wheelchairs.
   - Depending on the class’s excitement about the wheelchair project, you may want to test in the first half of the work period and allow them to redesign.
   - Have each group of students explain their design in front of the class. Then have the students test the chair based on the criteria they came up with. Example: To test for comfort, the bear must fit nicely in the chair. To test for strength, the chair must be pushed around without breaking. The students may be embarrassed if their chair collapses, but before they pick up their pieces and run back to their seats, be sure that they observe what parts broke and what parts did not.

3. **Wrap-Up** (10 minutes)
   - As a class, discuss some commonalities among the strong and weak parts of the wheelchairs.
   - Ask what was difficult, what was fun and what they would do differently if they could do the project again. What did they learn about building? What did they learn about engineering for a client?
Lesson 3: Fan-tastic (Part I)

Overview: The students will broaden their conception of a “robot.” They will become familiar with the brick and motors by building an NXT fan.

Learning Goals:
1. Students will practice building NXT robotics with the brick and motors.
2. Students will be able to explain what a robot is and give examples.

Materials:
- LEGO NXT kits (1 per 2-3 students)

Lesson Plan:
1. **Introduction** (10 minutes)
   - Lead a discussion about robots. Ask the students what they think a robot is. Ask them for some examples. Perhaps prepare videos, pictures or real live examples for the students to see. Be sure you explain that there are two different sides to robotics: building and programming.
   - Then tell the kids that they will build their own robot during class today. Explain that the brick is the brain of the robot, it tells the motor what to do. Then demonstrate how to add pieces to the motor (the orange part) to make them move.

2. **Main Activity** (30 minutes)
   - Explain that the students are to build an NXT fan. Show the students how to do simple programming on the brick. (No computers)

3. **Wrap-Up** (20 minutes)
   - Briefly discuss “programming.” Make sure the students understand that programming is giving instructions to robots. Ask the students if they can think of any examples of programming in their lives.
   - If time allows, do an abbreviated version of the Human Robot activity (see References). Otherwise, do it at the beginning of next class.
Lesson 4: Guided Programming Practice

Overview: This lesson will help students conceptualize programming with sensors. Then they will begin guided programming.

Learning Goals:
1. Students will be able to describe programming and where it is useful in their lives.
2. Students will practice giving detailed instructions to a person/robot.
3. Students will become familiar with the Mindstorms programming interface.

Materials:
- NXT robotics materials
- projector or paper programming
- 1-3 robots for programming demonstration

Lesson Plan:
1. Introduction (10-20 minutes)
   - Review the concept of programming.
   - Do Human Robot if not done last class.
2. Main Activity (40-45 minutes)
   - Introduce sensors by discussing how humans have senses. Have the students think about how they receive information, and how they respond. For example, if you hear a loud noise, you may cover your ears. Compare human senses to the NXT sensors. Robots don’t know what to do when they “hear” a loud noise, you must tell them.
   - To help the students better understand sensors, have them do a Human Robot activity in pairs or as a class (see References).
   - Introduce Mindstorms. Show the kids the relevant blocks (move blocks and “wait for”). Program as a class (see References).
   - Distribute computers and have the students open up their own Mindstorms program. Lead guided practice exercises. For example, write another program as a class and have the students follow along, recreating the program on their computers. Be sure that the pairs of students are taking turns placing each block. Choose 1-3 groups to download their program to the demonstration robot.
3. Wrap-Up (5 minutes)
   - Tell the students that next class they will be programming their fans from the previous week. Ask them to think about what they might want it to do.
Lesson 5: Fan-tastic (Part II)

Overview: After a review of programming with sensors, the students will program their own fan to change speed each time the touch sensor is pressed.

Learning Goals:
1. Students will understand that sensors allow the robot to “understand” the outside world.
2. Students will practice programming with the touch sensor.
3. Students will practice the create, test and redesign steps of the EDP

Materials:
• NXT robotics materials
• projector or paper programming bricks

Lesson Plan:
1. Introduction (10 minutes)
   - Use the first 10 minutes of class to review any material that was challenging for the students. Ask them what they learned last week.

2. Main Activity (45 minutes)
   - The students will now program their fan to run on three different speeds. Each time the touch sensor is pressed, it should change speed.
   - The students may have trouble programming as this is their first time. Encourage them to download and test their code often.
   - Make sure to introduce the idea of systematic debugging (may be best done in small groups, or with one pair.)

3. Wrap-Up (<5 minutes)
   - Ask the class what was challenging for them. How did they deal with those challenges?
Lesson 6: Welcome Bots

Overview: Students will make “Welcoming Bots” (or if it is Halloween time, “Trick-or-treat Bots”) that do something friendly (or spooky) when someone walks into the classroom.

Learning Goals:
1. Students will practice programming with the ultrasonic sensor.
2. Students will practice building.

Materials:
- NXT robotics materials
- projector or paper programming bricks
- spooky Halloween decorations, or other craft materials for the robots (optional)
- tennis ball (optional)

Lesson Plan:
1. Introduction (10 minutes)
   - Show the students how the ultrasonic sensor works either with a video (see References) or with a tennis ball demonstration.
2. Main Activity (45 minutes)
   - Give the students their challenge. Right now, no one would know that the classroom is full of engineers! The students’ job is to create a welcoming committee of robots that welcomes people into their classroom. (The robots will probably use the ultrasonic sensor to “see” someone coming, then say something, display something or move an arm to wave hello!)
3. Wrap-Up (< 5 minutes)
   - Ask the students if they have any questions about programming/robotics.
   - Tell them that they are ready to begin the final project!

Modifications:
- For groups that want to get more creative, bring decoration supplies
- If any groups finish early, encourage them to build more features onto their robot. For very advanced groups this could be a good chance to show how you can connect the ultrasonic sensor to the “play tone” block to make the tone get higher as the distance gets shorter.
Lesson 7: NXT Carnival (Part I)

Overview: The students will begin their final project which is to build a musical instrument, amusement park ride or attraction for the NXT carnival.

Learning Goals:
1. Students will practice brainstorming and planning projects.
2. Students will evaluate what is feasible with NXT robotics and what is not.
3. Students will practice working and cooperating in groups and teams.

Materials:
• NXT robotics materials
• project plan worksheets (1 per 2-3 students)
• craft materials and found materials

Figure 5. NXT Merry-Go-Round

Lesson Plan:
1. Introduction (5 minutes)
   o Look at some examples (pictures, videos, real examples) of carnival rides, moving attractions, carnival games, or musical instruments to inspire the students.
2. Main Activity (55 minutes)
   o Explain that their final assignment is to create an amusement park ride, game or musical instrument for the NXT carnival. Each project must use at least one sensor and at least one motor. Brainstorm as a class. This assignment is much more open-ended than the previous projects so it is helpful to prepare some example ideas to give the class an idea of what you’re looking for. Examples: Merry-Go-Round, mini-piano, ball thrower, etc.
   o Split the students up into groups and pass out the design proposal worksheets for the final project (see References). Be sure that each group clearly explains their plan to you before giving them their NXT kit/computers. It is crucial that their plan is feasible and within their capabilities. If their plan is not, work with the group to decide on a project that is!
   o Give the students time to work.
3. Wrap-Up
   o Collect their project proposal sheets to return to them next class. Make sure that students have requested any materials they will need next week.
   o Save the students’ Mindstorms programs (see References).
Lesson 8: NXT Carnival (Part II)

Overview: Students continue their final projects.

Learning Goals:
1. Students will practice collaborating with their group members.
2. Students will reinforce the programming and building skills they have learned thus far.

Materials:
- Computers with Mindstorms (1 per 2-3 students)
- LEGO NXT kits (1 per 2-3 students)
- completed project plan worksheets from last class
- found materials and craft materials
- any materials the students requested on their project proposal sheets.

Lesson Plan:
1. Introduction (15 minutes)
   - Have the students sit in a circle with their projects. Give each group the opportunity to briefly share how their project is going. Students should especially share if they are having a particular difficulty. Encourage other groups to give BOTH positive comments and helpful suggestions. Some classes do well with more guidance: for example, after a group shares their project ask for one positive comment and one thing the group could improve.

2. Main Activity (40 minutes)
   - Give the students time to work on their final project.

3. Wrap-Up (<5 minutes)
   - As the students are cleaning up, make sure that everyone’s program is saved to the STOMP Dropbox.

Figure 6. NXT Guitar
Lesson 9: Final Project (Part III)

Overview: The class will finish their projects and put them together to create an NXT carnival!

Learning Goals:
   1. Students will practice communicating their ideas to their classmates.

Materials:
   • LEGO NXT kits (1 per 2-3 students)
   • computers with LEGO Mindstorms (if the students need more time to program)
   • completed project plan worksheets from last class
   • craft materials and found materials
   • any requested materials

Lesson Plan:
   1. Introduction (30 minutes)
      o Give the students the first portion of class to finalize their robots.
   2. Main Activity (20 minutes)
      o Have each group set up a “stall” at the carnival. Allow one person from each group (Person A) to circulate and visit the carnival while the other member of the group (Person B) stays by their project to explain it to the other people that come by. After about 8 minutes, have the students switch roles. Person A now explains his/her group’s project to visitors while Person B wanders around to see his/her classmates’ projects.
      o Give the students some guidance about how they should talk to their classmates about their projects. Encourage them to ask questions such as: How did you come up with this idea? How did you program your robot? Remind the students to stay positive with their classmates.
   3. Wrap-Up (10 minutes)
      o The wrap up for your final class is up to you. You may lead a closing discussion in which you ask the students to think about some of the unit questions (See Notes). You may also have the student do a free write in which they must write (or draw) continuously for 5 minutes in response to a question you put on the board.
      o Thank the students for their hard work over the course of the semester!
**References**

**Setting classroom norms**
Setting classroom norms may seem unnecessary, but it will help greatly throughout the rest of the semester! Take the extra 5 minutes at the beginning of the unit. It will make it easier for you to correct bad behavior in later classes by referring back to the rules/norms.

One simple and effective way to create norms is by asking kids to complete the sentence “Good engineers...” Be sure that they answer positively. For example, “Good engineers give positive feedback to their partners.” instead of “Good engineers don’t criticize each other.”

**Human Robot**
Human Robot is a fun way to introduce students to the concept of programming. There are a variety of ways to lead the activity. Here are two examples:

1. As a class: One of the STOMPers pretends to be a robot. The other STOMPPer should help the students “program” him/her to complete a task in the classroom. The task can be anything from putting on socks and shoes (props required) to picking up an item and throwing it in the trash can. *Be sure that the students give specific in a way that is comparable to Mindstorms (e.g. have the students specify which leg--right or left-- the stomper should lift, just like the students have to specify the port of the motor that they want to move).*

2. In pairs: This activity is great for transitioning the students from thinking about programming conceptually to actually using the NXT Mindstorms technology. It is especially helpful to teach students about using sensors. As a class, write a simple program on Mindstorms. Then, put students into pairs. One student is the robot and the other one will interact with it to “activate” its sensor (i.e. poke their partner’s arm because it is the touch sensor).

**Programming as a Class**
Programming as a class is a great way to introduce the programming technology. Like Human Robot, this activity can be altered depending on your classroom and teaching style.

Using a projector or paper programming blocks, demonstrate to the class how to write a Mindstorms program. It is important that you keep the class engaged by asking the class for advice and suggestions along the way. It’s important to ask a wide variety of students, not just those that raise their hands. After writing the program, download and test the program on a pre-made robot. The kids get excited when they see their
program in action! If there are any bugs, systematically debug as a class. Debugging can be one of the most valuable parts of programming as a class.

Ultrasonic Sensor Demonstration
Stand about 4 feet from a wall and bounce the tennis ball against the wall. Ask the students to predict. “Will the ball take more or less time to return to me if I back up?” Show that it takes more time. Move closer to the wall and demonstrate the opposite. Explain that the ultrasonic sensor sends out waves (instead of a ball) and measures the time it takes to come back. This demonstration is helpful as students often confuse the ultrasonic sensor for a camera.

Video: Click “next” in the upper righthand corner to go to the page with the video. http://www.education.rec.ri.cmu.edu/previews/nxt_products/robotics_eng_vol_1/preview/content/reference/helpers/ultrasonic.htm

Saving Student Work from Week to Week
To save students’ programs on Mindstorms from week to week, save them to the STOMP Dropbox. It’s on all the CEEO laptops or can be accessed through the internet. Please save your students work neatly in a folder labeled with you teacher’s name and your school. If, for whatever reason, you cannot use the STOMP Dropbox, save the students’ work to the computer desktop under their names. Then make a written record of which students were using which computers. Do not label the computers as tape can leave adhesive marks and post-it notes fall off. Bring the same computers back to the next class.
Design Worksheet for NXT Carnival

For your final project, you will need to design and build a miniature ride, a musical instrument or a game for our NXT Carnival!

You may use any parts from your LEGO NXT kit and other STOMP materials. It has to use at least ONE sensor and at least ONE motor.

Briefly describe your carnival attraction.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Which sensor will you use? ________________________________________________

What will happen when the sensor is activated? ______________________________

________________________________________________________________________

Please request any additional materials you will need for your project.

________________________________________________________________________

On the back of this page, draw a picture of your NXT carnival attraction. Label the brick, the sensor(s) and the motors on your drawing.

STOMPer Approval: ________________________________
Image Bibliography

Figure 2. NXT Fan

Figure 3. “Wait for Touch” NXT Block
https://manual.eg.poly.edu/images/6/68/Lab_sensors_30.jpg

Figure 4. NXT Fan
http://sites.tufts.edu/stompactivitydatabase/files/2013/06/Introduction-to-Robotics.pdf

Figure 5. NXT Merry-Go-Round
http://www.legoengineering.com/wp-content/uploads/2013/06/e.jpg

Figure 6. NXT Guitar
http://www.nxtprograms.com/guitar/DCP_3026.JPG