Introductory Programming with EV3 Robotics

STOMP Curriculum
June 2014
Notes

Description
This is a 9-week unit designed to give upper elementary and middle school children an introduction to programming with LEGO EV3 Robotics. Each lesson is designed to be 60 minutes long, but may be adapted for a longer or shorter block of time.

The purpose of this unit is to teach the basic concepts of programming. The curriculum is intended to give students more time to program by reducing the amount of time spent on building each robot. By the end of the unit, students should have confidence using LEGO Mindstorms.

For all lessons, you will need laptops with EV3 Mindstorms software (1 for every 2 students) and EV3 robotics kits (1 for every 2 students). These materials will be referred to simply as “EV3 Robotics materials” on the activity pages.

In Practice
Before going into the classroom, thoroughly familiarize yourself with the LEGO 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.

First learning to program can be very challenging for students. To keep students from getting frustrated and losing focus, consider beforehand what you want your students to spend time on. For example, if a student is struggling to connect his/her programming blocks, you should enable their progress by showing them where to place the blocks. On the other hand, if a student is trying to figure out how to make a robot arm wave, guide him or her to think about what motions the motor should make.

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 can you make the activities relevant to the real world? What interpersonal skills do you want them to practice? How will you know if your curriculum is successful?

Questions for Your Students to Think About
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Lesson 1 What is Programming?

Overview: In the first lesson of the unit, students will develop a set of classroom rules, and build cars to use in future lessons.

Learning Goals:
1. Students will be familiar with the EV3 kit.
2. Students will be familiar with STOMP.

Materials:
- LEGO EV3 robotics kits
- car building instruction packets or equivalent building aid

Lesson Plan:
1. **Introduction** (10 minutes)
   - Begin by introducing yourself, STOMP and this programming unit.
   - Discuss classroom behavior (see References). Record the responses on the board and leave them there for the class period for you to refer back to if you see inappropriate behavior.

2. **Main Activity** (45 minutes)
   - Give the students some time to explore the EV3 kits and build a simple car. It should have 2 motors, both facing in the same direction. There should be a place where the student can tape on markers for the ArtBots activity. If a group finishes early, encourage them to design a LEGO structure to hold the markers on the car.
   - Be sure to explain that there are many other types of EV3 robots—you can even pull up some videos—and that you are building these cars so that the students would be able to spend more time programming.

3. **Wrap-Up** (5 minutes)
   - Ask the students what they thought about the building. What was difficult? What was easy? Did anyone make a discovery they’d like to share with the class?

Modifications:
- If you want to accelerate the class, you can pre-build the cars yourself and pack them into the EV3 kits for the students to use. Then, spend the majority of class doing an introduction to programming (see Lesson 2).
Lesson 2 ArtBots

Overview: This class introduces students to the concept of programming, and to Mindstorms. Students will use only the movement commands to draw a picture on a piece of poster paper.

Learning Goals:
1. Students will be able to explain programming and give examples.
2. Students will familiarize themselves with the basics of Mindstorms.
3. Students will practice writing programs with the movement blocks.
4. Students will learn about systematic troubleshooting/debugging.

Materials:
• EV3 robotics materials
• projector or paper programming bricks
• markers and poster paper (may already be in classroom)

Lesson Plan:
1. Introduction (20 minutes)
   o Ask the students, “What is programming?” Come up with real world examples together.
   o Do the Human Robot activity (see References).
2. Main Activity (35 minutes)
   o Introduce the students to Mindstorms and the relevant blocks (movement blocks, wait for time). Program as a class (see References). Download a program onto an EV3 car to demonstrate. Then distribute computers and EV3 cars. Have them write and test the same sequence of blocks. Circulate and troubleshoot.
   o If there’s time, begin the ArtBots activity. Students are to draw a picture (can be an abstract picture!) by programming the car with only the movement blocks.
   o Remind the kids to take turns programming (see References for helpful tips).
3. Wrap-Up (< 5 minutes)
   o Discuss the activity. Was it easy or hard?
   o Ask the students to make predictions. What else do you think you could program the robot to do?

Modifications:
• If you do not have the drawing materials, make a simple maze with the EV3 boxes and have the students use the movement blocks to navigate the maze.
Lesson 3 Touch Sensor Challenges

Overview: Program as a class to introduce the students to the sensor blocks, then have the students complete a series of challenges.

Learning Goals:
1. Students will practice programming with the touch sensor.
2. Students will practice testing and redesigning their program

Materials:
- EV3 robotics materials
- projector or paper programming bricks

Lesson Plan:
1. Introduction (15 minutes)
   - Show the students the 4 sensors in their EV3 kits. Explain what each one does.
   - Do the Human Robot activity in pairs, focusing on sensors (see References).
2. Main Activity (45 minutes)
   - Program as a class with a projector or the large paper blocks. Introduce the “wait for” block and show them how to set the time set to “unlimited.” Do this by asking leading questions. Write a program as a class and give the students opportunities for guided practice. It can be helpful to do this in half class or smaller groups.
   - Give the students some (approximately 6-8) very simple challenges to complete with the touch sensor. Each challenge should build on the previous challenge so that only 1 block of the previous program needs to be changed. For example:
     1. move forward, waiting until touched, then move backwards for 5s
     2. waits until touched, then twists side to side 10 times.
     3. wait until touched, then twist side to side infinitely (loops!)
     4. start forward, then switch direction each time the touch sensor is touched.
   To make it more fun, give the whole class one challenge, and then give groups new challenges individually as they are ready for them—the class will really get into the race aspect.

Modifications:
- If the students finish quickly, let them try the challenges with a different sensor or just give them additional challenges.
- If the students really liked the ArtBots activity, incorporate challenges with drawing.
Lesson 4 EV3 Alarm

Overview: This lesson is a flexible lesson. If your students need more practice using sensors, this lesson will give them additional practice programming with the ultrasonic, light, or sound sensor. If your students have strong understanding of programming with sensors, feel free to skip this week, or give them a more challenging task.

Learning Goals:
1. Students will practice programming with the ultrasonic or sound sensor.
2. Students will practice applying the engineering design process in its entirety.

Materials:
- EV3 robotics materials
- tennis ball for ultrasonic sensor demonstration

Lesson Plan:
1. Introduction (5 minutes)
   - Explain how the ultrasonic sensor works either with a short video or with a tennis ball demonstration (see References).
2. Main Activity (50 minutes)
   - The challenge for this week is for the students to build an EV3 security alarm. Create a back story that links the engineering curriculum to the real world or other parts of the class’s curriculum. Perhaps the alarm will be put in the classroom to protect from other people coming into the classroom. Perhaps it can be used to protect the Egyptian pyramids from tomb raiders.
   - Depending on the context, the alarm can be triggered by the ultrasonic sensor, light sensor or the sound sensor. The STOMPers may choose the sensor for the whole class or let each group choose. The students should add the sensor to their cars so it remains intact for the next lesson.
   - Give the students the remainder of class to build their alarms.
3. Wrap-Up (5 minutes)
   - If time permits, let some groups volunteer to share their alarms with the class or let the students circulate and share their projects with one another in an organized way. If the teacher wants students to practice presentation skills, have the students share group by group.
Lesson 5 Seeing-Eye Dog

Overview: Program as a class to introduce the students to loops in programming. Then students will design robotic seeing-eye dogs.

Learning Goals:
1. Students will practice using loops to program repeated actions.
2. Students will practice testing and improving their program.

Materials/Preparation:
• EV3 robotics materials
• the boxes of the EV3 kits (already in the class)
  o Use the EV3 boxes to set up a short obstacle course
• Other obstacles (optional)

Lesson Plan:
1. Introduction (10 minutes)
   o Ask the class what they did last week? Who remembers something cool about programming?
   o Explain how loops work. Program as a class. Write a program that uses a loop. Download and demonstrate the program.

2. Main Activity
   o Present the seeing-eye dog challenge. Students must try to get their LEGO figurine through the obstacle course without hitting the obstacles.
   o Review the EDP. Before passing out the cars, kits and computers, have the pairs talk to one another to plan which sensor they will use.
   o Let the students work on their program. Refer back to the EDP to encourage frequent testing and improvement.

Modifications:
• For groups that finish more quickly:
  o Teach the students how to make sounds on the EV3 or display images.
Lesson 6 Nighttime Creepers/Freeze Dance

Overview: Program as a class to introduce the concept of switches in programming. Choose between the two activities.

Learning Goals:
1. Students will practice programming with switches.
2. Students will practice programming with the light or sound sensor.

Materials:
• EV3 robotics materials
• projector or paper programming bricks
• spooky Halloween decorations for the robots (optional)

Lesson Plan:
1. Warm-Up (10 minutes)
   o Introduce the last programming concept: switches. As a class, program a simple example program using the sound sensor. If the noise is below a certain level, the robot will do something. If it is above that level, it should do something else. If your students seem to be grasping programming, you can let them explore this on their own.

2. Main Activity (50 minutes)
   o Nighttime Creepers: The students are to make were-robots that act “normal” when the lights are on, but do something crazy and spooky when the lights are off! This is a good opportunity to show the students how to make noises or display images on the EV3. Also encourage them to reconstruct parts of their pre-built car (i.e. replace the wheels with scary legs!)
   o Freeze Dance: The students are to make a robot that stays still when the sound is below a certain level and “dance” when it is above a certain level.
   o Before building, determine a threshold, for the switch. Use the datalogging or “VIEW” feature of the EV3 to measure the ambient light or noise in the classroom.

Modifications:
• If groups finish early:
  o encourage them to use another sensor to practice parallel programming
  o encourage them to build more features onto their robot or decorate it!
• If the class is not ready to learn about switches, skip them altogether. You can adapt this lesson to be a more simple programming challenge by having the robots simple wait until the lights go off, then do something creepy for a set amount of time.
Lesson 7 The Perfect Pet (Part I)

Overview: The students will begin their final project, to build and train “The Perfect Pet.”

Learning Goals:
1. Students will practice planning as they design their projects.
2. Students will apply and reinforce their programming knowledge.

Materials:
• EV3 robotics materials
• project plan worksheets (1 per 2-3 students)

Lesson Plan:
1. Introduction (5 minutes)
   - Present the final project: You want a new pet; however someone in your family is allergic to animals with fur and afraid of everything else. You decide that you will build yourself your own perfect robotic pet! Your pet must use at least two different sensors to interact with you.

2. Main Activity (45 minutes)
   - Pass out the project plan worksheets (see References). Give the students time to brainstorm and fill them out. Conference with each group and ensure that their idea is feasible before approving it. Help steer students toward ideas you know are achievable in this time frame. Your guidance and involvement during the beginning steps is crucial.
   - Let the students work on their pets. Make sure that the students save their work. (See References for tips on saving students’ programs from week to week)

3. Wrap-Up (10 minutes)
   - Have the groups share their projects to the class (quickly, at their desks). Allow the other students to give feedback. Be sure that it is positive and/or constructive. You may need to guide the discussion by asking for one compliment and one suggestion after each presentation.
   - Collect their project plan worksheets. Review them with your STOMP partner to be sure that students are on the right track. Bring the worksheets back the following class.

Modifications:
• If you think it would be helpful, start with a whole class brainstorm before breaking them up into their groups
Lesson 8 The Perfect Pet (Part II)

Overview: Students continue their final projects.

Learning Goals:
1. Students will practice programming with multiple sensors in Mindstorms.

Materials:
• EV3 robotics materials
• completed project plan worksheets from last class
• craft materials to decorate the robots (optional)

Lesson Plan:
1. Introduction (10 minutes)
   o Have each group share what part of the project they will work on during class. Be sure that all groups are on schedule. Take note of each group’s progress so that you can give more help to groups that are behind schedule.
2. Main Activity (50 minutes)
   o Give the students time to work on their final project. They should finish programming their robots by the end of this class period.

Figure 2. NXT Puppy
Lesson 9 The Perfect Pet Presentations

Overview: Students will finish their projects and present their perfect pets!

Learning Goals:
1. Students will practice communicating their ideas to the class.
2. Students will evaluate their work and reflect on the design process.

Materials:
- EV3 robotics materials
- craft materials to decorate the robot (optional)

Lesson Plan:
1. Introduction (15 minutes)
   - Give the students the first portion of class to finish their robots. They should have completed programming last week. This time should be dedicated to creative touches and physical features.
2. Main Activity (35 minutes)
   - Have the class sit in a circle. Groups should sit together. Set expectations for the presentation (e.g. every member of the group talks). Go around the circle having each group present their “perfect pet.”
   - If time permits, let one person from each group circulate and talk to their classmates about their projects. The other person stays with their project to explain it. Then switch so the other partner can walk around and see other students’ work up close.
3. Wrap-Up
   - Option A: Lead a discussion to wrap up the unit as a whole. Example questions: What was your favorite/least favorite part of the unit? What was the most challenging part? What is the most important thing you learned?
   - Option B: You may consider doing a free write. Give the students a guiding question (e.g. What was your favorite part of STOMP?) and have the students write or draw (without stopping!) for 5 minutes. Their free writes are fun to read afterwards!
   - Thank the students for all their hard work this semester!
References

**Setting Classroom Behavioral Norms**
Setting classroom rules 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 listen carefully while others are talking.” instead of “Good engineers don’t talk while other people are talking”

**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 STOMPer 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—you can even just go in a set order through everybody. 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.
Working in Groups
All of the activities should be done in pairs (or if necessary groups of 3) so that each student gets the chance to use Mindstorms. To foster sharing and collaboration, have the students alternate who is at the computer for each challenge or every 5 minutes. Remind the students that even if they are not touching the computer, they can still contribute ideas to programming.

For larger, more open-ended projects, such as the final project, it can be helpful to have students adopt roles such as “the programmer” or “the builder” (or “the communicator” if in groups of 3). These labels give students a chance to focus on the aspect of robotics they like best and help students delegate work.

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 your 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. You can also move all the programs from the desktops to the Dropbox when you get back to the CEEO.
**The Perfect Pet Project Plan**

Imagine that you (or a friend) desperately want a pet. Unfortunately, your dad is allergic to anything with fur and your little brother is afraid of anything without fur. You decide that if you can’t adopt a pet, you’ll make one!

Using any parts from your LEGO EV3 kit and other STOMP materials, make your own perfect pet! It does not have to be based on a real animal, but it does have to use at least ONE sensor and at least ONE motor.

Briefly describe your pet. What will it be able to do?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Which sensor will you use?

________________________________________________________________________

What will happen when the sensor is activated?

________________________________________________________________________

Please request any additional materials you will need to create your pet.

________________________________________________________________________

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

**STOMPer Approval:** ____________________________________________
Image Bibliography

Figure 1. Simple NXT Car

Figure 2. NXT Puppy
http://nxtprograms.com/puppy/DCP_4730.JPG