FIRST League Robotics WOW! Unit Plan

Robotics is a rapidly growing field in computer science. This apprenticeship teaches basic robot design to middle school students that culminates in a judged competition (WOW!). This competition includes a teamwork interview, research presentation, and a robot demonstration. Through applied knowledge of computer programming (NXT), research and design, developed problem-solving skills, and intense collaboration with team members, students construct their own basic robots and research presentation that result in a unique solution to a problem related to the challenge theme. Students also learn to demonstrate knowledge of how and why such robots operate the way they do. Included in this curriculum are explicit connections to career options and educational experiences necessary to fulfilling a career in robotics design.

KEY SKILLS AND OUTCOMES FOR STUDENT LEARNING

Computer Science and IT Standards	21ST Century Skill(s)
CS.CSITS.2: Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions. a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem. c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.) d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols. e. I can **summarize how to design and operate** a robot, computer game, or other computational artifact that uses functions to solve problems. (WOW!) f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)	**Oral Communication:** The ability to speak to an audience with confidence using eye contact and body language speaking to groups, demonstrating confidence, speaking more comfortably in front of an audience, developing coherent and well-organized content. **Technology:** The ability to identify and use technology as a tool **Leadership:** The ability to make decisions, establish goals, volunteer to help other students, role model by focusing on and completing work, following directions, and guiding others to do so.
CS.CSITS.3 Citizen schools students will collaborate and effectively work in teams to produce computational artifacts a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts. b. I can **collaborate with other team members** to complete computer science projects. c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion. d. I can **constructively evaluate my and others' performance** in a particular team role.	

CS.CSITS.5 Citizen schools students will compare and contrast the ways in which computing enables innovation in other fields.

a. I can **make comparisons between skills learned and identified careers in computing**, including - but not limited to - information technology specialist, Web page designer, systems analyst, programmer, and CIO.

COLLEGE/CAREER CONNECTIONS

For this apprenticeship, college/career connections are specifically emphasized on Weeks 5-6 (see Scope and Sequence below). Though such connections are not specifically referenced as standards or objectives for each week, Citizen Teachers are strongly encouraged to make connections as the opportunities to do so present themselves in their weekly interactions with students. For example, throughout the apprenticeship, teams will encounter challenges similar to those faced by scientists and engineers as they identify a problem and develop an innovative solution.

GUIDING QUESTIONS

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?
What role does team work play in programming and constructing a robot?
How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

WOW! DESCRIPTION

The WOW! culmination will be two-fold. For each team, there are a research sub-team and robotics-based sub-team (design and programming). Each team will be expected to present their research findings highlighting an innovative solution to the challenge-based problem. Each team will also perform a robotics demonstration that connects to the challenge problem by showcasing what the basic robot can do.. At a minimum these robots will be able to move around and interact with their environment in some way (solving a problem). Students should also be able to orally demonstrate their understanding of robot construction (e.g., programming involved) and showcase the operations of their team-built robots.

MATERIALS

USFIRST.org

- Tournament dates
- Registration Materials
- Official Tournament Rules
- Additional Support
- Coach’s Handbook (upon request)

- Tournament Format Details
- Competition practice mats (to be purchased)

Ortop.org/NXT_Tutorial/

NXT programming can be tricky for volunteers who have never used the program. This website provides helpful, step by step video tutorials on Lego NXT programming.

http://www.thetech.org/robotics/

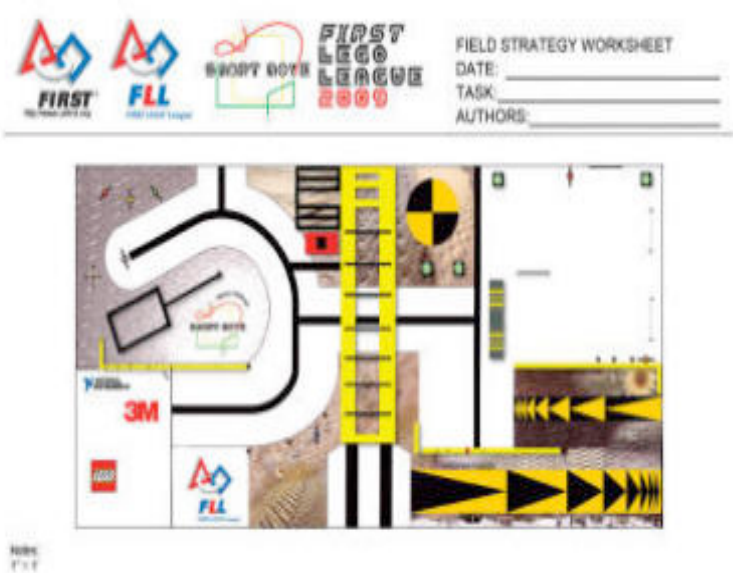
This is a great website for robotics teaching activities and history of robots.

http://nxtprograms.com/projects1.html

This website has design ideas with step by step instructions on how to build NXT robots. It is recommended to create a generic robot to practice programming immediately.

Materials:

1. Competition Mat- Purchased through USFIRST.org



2. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)

3. Extra Lego pieces for barriers on the competition mat.

4. 4- 6 computers- (4 with NXT software installed)

Team Format:

- The ideal format for the FLL Robotics apprenticeship is a minimum of **two adult volunteers, 1 Citizen Schools support staff, and a maximum of 16 students.**
- Each apprenticeship will have 2 teams, with each team having 6-8 students and one adult volunteer.

Ideal team format:

Adult Volunteer

Programming Team
(2- 3 students)

Design Team
(2 Students)

Research Team (3 Students)

Specific Materials

1. 1 bag of multi-colored Starbursts.
2. Develop a list of 10-12 questions regarding your specific classroom expectations. (These will be used as an informal assessment at the end of the lesson.)
3. Develop a list of 3-4 questions regarding the three different team member roles and the basic expectations of the FLL challenge.. These will also be used as an informal assessment at the end of the lesson.
   Note: Each of these questions should be able to be answered in concrete answers that are no more than a few words.
4. FLL Video (Introduction, as posted on website) and accompanying technology
5. 14-15 “Team Member Role Rating” slips
6. WOW! Introduction Information, Class Expectations Overview
7. Display screen connected to teacher computer (modeling)
8. One large notecard per student.
9. Writing utensils for each student.
10. Access to file storage and/or printing for data collection (research team)
11. FLL Challenge Information (Hard copy printed out)
12. Competition Mat- Purchased through USFIRST.org
13. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
14. Extra Lego pieces for barriers on the competition mat
15. Presentation boards for research teams (See example research projects online for First Lego League)
16. Presentation design materials for research teams (See example of research projects online for First Lego League)
17. Snacks and drinks for celebration at end of apprenticeship!
18. Large display board for teamwork interview practice preparation.

The “Teaching Robotics” PowerPoint is a great resource in terms of introducing students and teachers to the fundamentals of teaching a robotics curriculum. The PowerPoint offers suggestions for managing resources, (including time, money, and staff) and it additionally offers example robotics programming activities and slides to be potentially used with students for various lessons.

What will also be a very useful source is the FLL Coaches’ Handbook, issued each year in preparation for the competition. In this handbook, teachers, will get very specific information to support the learning of students, including information on materials, maechanics, the specific project steps, checklists, schedules, rubrics, terms, and concepts. **Perhaps most important is the section describing the necessary pre-season preparation for the coach.**

BASIC WOW! PLAN

Week	WOW! Connection
1	In this lesson, students will become familiar with the FIRST competition aspects, the goals of robotics programming, and Lego pieces. A strong foundational understanding of the competition and the essential materials will be crucial to setting the tone for a successful WOW! product.
2	Students will be divided into teams for the competition. The research team will take a more detailed look at the challenge (WOW!) expectations (via the competition rubric). The design team will begin the design process for the robots, while the programming team will begin practicing basic programming based on the challenge problem presented.
3	With a focus on the WOW! product and presentation, the design team will work towards a better understanding of the missions on Robotics Course while the research team will decide on a research project to pursue. The design team will choose a robot design best suited for the course objectives. Students will also begin a series of team-building activities as teamwork will be a major judging factor for the challenge (WOW!).
4	As the mid-point of the challenge (WOW!) approaches, students in the research team will draw conclusions from data collected (and decide on a research strategy), while students of the design team will finalize the robot design. Programming team students will continue to practice basic programming skills, this time using the challenge competition mat for the first time.
5	As the midpoint of the apprenticeship, students in the research team will finalize the solution they developed based on data summary (corresponding to FLL challenge.) The design & programming team collaborate to confirm that the robot design developed is the best design for the course. This is important as robot navigation of the obstacle course is a major component of the FLL challenge (and WOW!).
6	As the mid-point of the challenge (WOW!) approaches, students in the research team will draw conclusions from data collected (and decide on a research strategy), while students of the design team will finalize the robot design. Programming team students will continue to practice basic programming skills, this time using the challenge competition mat for the first time.

7 & 8	As extensive work sessions for completion of the WOW! product and FLL challenge, students will finish the research posterboards, begin preparing for final presentations (research teams), and complete the last two robotics programming tasks (programming and design teams) according to challenge mission. (Students should also get FLL permission slips signed if they have not yet done so.)
9	Students will finalize last details of their respective team's robots (including building and programming),identify the specific role that they will have for the WOW! presentation and begin formal rehearsals of those parts.
10	Students will apply their understanding of their respective WOW! roles, robotic construction, and programming through clear presentations for ceremony (as individuals and cohesively as groups.)

LESSON PLANS AT A GLANCE (SCOPE AND SEQUENCE)

	Week	<u>Learning Objectives</u> By the end of the lesson, each student will be able to:	CS Standards & 21st Century Skills	Specific Activities & WOW! Connection
What role does team work play in programming and constructing a robot?	**1** Learn new skills *Model*	▪ Identify and explain the major aspects of the FIRST Lego League competition. ▪ Explain the fundamental goals of programming a robot. ▪ Explain class expectations for apprenticeship. ▪ Differentiate the roles of team members in First Lego League.	Oral Communication Technology CS.CSITS.2 a CS.CSITS.3 a	1. Welcome and Introductions (Starburst Game) 2. FLL Video (available upon request on USFIRST.org) 3. WOW! Expectations (Discussion) 4. FLL Format, & Team Role Presentation 5. Apprenticeship timeline and assessment. WOW! Prep: In this lesson, students will become familiar with the FIRST competition aspects, the goals of robotics programming, and Lego pieces. A strong foundational understanding of the competition and the essential materials will be crucial to setting the tone for a successful WOW! product.

In what ways can robots be used to solve certain problems, and what are the limitations of a robot? *What role does team work play in programming and constructing a robot?*	**2** Learn new skills *Model*	• **Explain expectations** of the FLL Research Project Challenge- and the **major aspect**s that will be used to judge its success (rubric.) • **Apply** learned basic knowledge of robots/NXT programming by **successfully operating** robots/performing basic computer programming. • **Define teamwork** and **explain its connection** to completion of WOW! product.	Oral Communication Technology CS.CSITS.2 a CS.CS.3 a, b, c	1.Hook/Introduction (What can robots do?) 2. Teamwork Discussion & Team Divisions 3. Research Team (Rubric and Successful Examples) Design/Programming Team (Programming Tutorial) 4. Assessment and WOW! Connection WOW! Prep: Students will be divided into teams for the competition. The research team will take a more detailed look at the challenge (WOW!) expectations (via the competition rubric). The design team will begin the design process for the robots, while the programming team will begin practicing basic programming based on the challenge problem presented.

In what ways can robots be used to solve certain problems, and what are the limitations of a robot? *What role does team work play in programming and constructing a robot?* *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*	**3** Learn new skills *Model*	▪ Utilize understanding of teamwork to successfully complete a team-building activity. ▪ Collect and organize research data *relevant* to problem as presented by competition challenge (research team) ▪ Build the robotics obstacle course (design team) ▪ Analyze the robotics course to assess implications for robotics design (design team) ▪ Utilize knowledge of programming to program basic robotics operations (programming team)	Oral Communication Technology CS.CSITS.2 a, b, d CS.CSITS.3 a, b, c	1, Hook: Robot teaser ritual 2.Team Building Activity ("The Body") 3. Work Session (Research, Design, and Programming) 4. Assessment and WOW! Connection WOW! Prep: With a focus on the WOW! product and presentation, the design team will work towards a better understanding of the missions on Robotics Course while the research team will decide on a research project to pursue. The design team will choose a robot design best suited for the course objectives. Students will also begin a series of team-building activities as teamwork will be a major judging factor for the challenge (WOW!).

In what ways can robots be used to solve certain problems, and what are the limitations of a robot? *What role does team work play in programming and constructing a robot?* *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*	**4** Produce *Scaffold*	▪ Draw conclusions from collected research data as they inform possible solutions to competition challenge to robotics solutions (research team) ▪ Design presentation boards (research team) ▪ Complete robotic design (design team) ▪ Perform program operations using the FIRST competition mat (programming team) ▪ Evaluate the impact of positive team encouragement on individual performance	Oral Communication Technology CS.CSITS.2 a, b, d CS.CSITS.3 a, b, c	1. Hook (Robot operation ritual) 2. Teamwork and positive language activity 3. Research, Design, and Programming Team (Working Sessions) 4. WOW! Connection and Assessment WOW! Prep: As the mid-point of the challenge (WOW!) approaches, students in the research team will draw conclusions from data collected (and decide on a research strategy), while students of the design team will finalize the robot design. Programming team students will continue to practice basic programming skills, this time using the challenge competition mat for the first time.

In what ways can robots be used to solve certain problems, and what are the limitations of a robot? *What role does team work play in programming and constructing a robot?* *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*	**5** Produce *Scaffold*	▪ Create relevant, organized, and creative props and visuals to include on research presentation board (research team) ▪ Design the style and anticipated functions of the team robot (design team) ▪ Perform program operations using the FIRST competition mat (programming team) ▪ Explain the educational and career paths of volunteers who have robotics or programming-based careers.	Oral Communication Technology CS.CSITS.2 a, b, d CS.CSITS.3 a, b, c CS.CSITS.5 a,	1. Hook (Robot operations ritual) 2. Robotics Careers (Volunteers presentation) 3. Programming, Design, and Research Work Sessions 4. Assessment and WOW! Connections WOW! Prep: As the midpoint of the apprenticeship, students in the research team will finalize the solution they developed based on data summary (corresponding to FLL challenge.) The design & programming team collaborate to confirm that the robot design developed is the best design for the course. This is important as robot navigation of the obstacle course is a major component of the FLL challenge (and WOW!).
What role does team work play in programming and constructing a robot? *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?* *In what ways can robots be used to solve certain problems?*	**6** Practice *Scaffold*	▪ Summarize opportunities available for pursuing interest in robotics at high school level. ▪ Create relevant and creative visuals to incorporate into research presentation (research team) ▪ Complete necessary program tasks (1 and 2) as required by competition mat.	Oral Communication Technology Leadership Oral Communication Technology CS.CSITS.2 a, b, d CS.CSITS.3 a, b, c CS.CSITS.5 a,	1. Hook (Robot operations ritual) 2. Pursuing robotics in high school 3. Programming/Design and research work sessions] 4. WOW! Connection and Assessment WOW! Prep: As part of the development of the final challenge (WOW!) products, the research team will type and create visuals for the presentation board. The programming sub-teams will work on completing the first two major tasks that the robot will need to be able to perform for the FLL challenge (WOW!) .

What role does team work play in programming and constructing a robot? *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?* *In what ways can robots be used to solve certain problems?*	**7 & 8** Practice *Coach*	▪ Create a research project and presentation that is creative, entertaining, and is solution-oriented according to FLL challenge (research team) ▪ Design and program robot to complete at least 4 major tasks. (design and program teams.)	Oral Communication Technology Leadership Oral Communication Technology CS.CSITS.2 a, b, d CS.CSITS.3 a, b, c	Work session as needed. In tailoring lesson plan, teachers should might want to strongly consider connections to guiding questions. WOW! Prep: As extensive work sessions for completion of the WOW! product and FLL challenge, students will finish the research posterboards, begin preparing for final presentations (research teams), and complete the last two robotics programming tasks (programming and design teams) according to challenge mission. (Students should also get FLL permission slips signed if they have not yet done so.)

What role does team work play in programming and constructing a robot? *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?* *In what ways can robots be used to solve certain problems?*	**9** Practice *Fade*	▪ **Apply their knowledge** of project-based research, robotics design, programming, and teamwork through effective, creative presentations and products (robots) for WOW! ceremony and FLL challenge.	Oral Communication Technology Leadership CS.CSITS.2 a, c, d, e, f CS.CSITS.3 a, b, c, d	1. Teamwork Interview Practice/Preparation 2. Work Sessions (Including practice of presentations and programming tasks.) 3. WOW! Connection and Assessment WOW! Prep: Students will use this time for in-depth preparation for the WOW! and FLL challenge. Specifically, the research team will perform detailed rehearsals of presentation, while the programming and designing teams will make the final tweaks to the programming tasks. Rehearsals will also be done as a group after students are oriented in detail to the FLL Challenge agenda.
What role does team work play in programming and constructing a robot? *How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?* *In what ways can robots be used to solve certain problems?*	**10** Practice *Fade*	▪ **Apply their knowledge** of project-based research, robotics design, programming, and teamwork through effective, creative presentations and products (robots) for WOW! ceremony and FLL challenge.	Oral Communication Technology Leadership CS.CSITS.2 a, c, d, e, f CS.CSITS.3 a, b, c, d	1. Rehears as needed WOW! Prep: Final rehearsal, preparation, and practice for WOW! research presentation and robot demonstration.

Robotics I - Lesson 1

This lesson introduces the apprenticeship to students. Through discussions and other informal activities, students become familiar with class and teamwork expectations, the FLL robotics competition, and expectations for the WOW! Presentations.

Objectives

a. Identify and explain the major aspects of the FIRST Lego League competition.
b. Explain the fundamental goals of programming a robot.
c. Explain class expectations for apprenticeship.
d. Differentiate the roles of team members in First Lego League.

Lesson Snapshot:

1. Welcome and Introductions (Starburst Game)
2. FLL Video (available upon request on USFIRST.org)
3. WOW! Expectations (Discussion)
4. FLL Format, & Team Role Presentation
5. Apprenticeship timeline and assessment.

Vision for *Student* Mastery:

Various oral assessments will be given throughout the lesson as consistent "check points" for understanding. At the end of the lesson, students will be given a "mini-quiz" of answers to review questions that pertain to the basics of the FLL challenge, class expectations, and their understanding of different team roles for completing the apprenticeship. These will serve as their "exit slips" out of class. (Students should turn in completed answers to teacher upon their exit of the classroom.)

Materials and Pre-Planning

1. 1 bag of multi-colored Starbursts.
2. Develop a list of 10-12 questions regarding your specific classroom expectations. (These will be used as an informal assessment at the end of the lesson.)
3. Develop a list of 3-4 questions regarding the three different team member roles and the basic expectations of the FLL challenge.. These will also be used as an informal assessment at the end of the lesson.
   Note: Each of these questions should be able to be answered in concrete answers that are no more than a few words.
4. FLL Video (Introduction, as posted on website)
   and accompanying technology
5. 14-15 "Team Member Role Rating" slips
6. WOW! Introduction Information, Class Expectations Overview
7. Display screen connected to teacher computer (modeling)
8. One large notecard per student.
9. Writing utensils for each student.

CSITS Standards

CS.CSITS.2
Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.

CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.

Connection to Guiding Questions

What role does team work play in programming and constructing a robot?

WOW! Scaffolding

In this lesson, students will become familiar with the FIRST competition aspects, the goals of robotics programming, and Lego pieces. A strong foundational understanding of the competition and the essential materials will be crucial to setting the tone for a successful WOW! product.

The Hook/Introduction - 45 minutes

Ask students to raise their hands and respond to the following questions.

What do you all know – or think you know - about robots?
Why do you think people make them?
Has anyone ever played with Lego's?
Do you think there's any connection between Lego's and robots?

Transition: *Thank you for your responses. Based on some of the things I heard, I think you all are really going to enjoy this apprenticeship. In this apprenticeship, you will design robots out of Lego's, learn how to program your robots and compete in a national tournament in 10 weeks! But before we jump into robots, we're going to do a little activity to help us get to know each other a bit better.*

Get to know you game – Starburst (What's Your Flavor?") - With your bag of starbursts, have each student pick two starbursts from the bag, but tell them they may not eat the starburst yet. Go around the classroom & ask each student to say their name and share their interesting fact based on the starburst color that they picked

Red: Favorite movie
Yellow: Favorite food
Orange: Favorite Superhero
Pink: Favorite band

(Note: Any other "get-to-know-you" game would suffice here as well.)

Transition: *Now that we know each other a bit better, let's take a closer look at what you all will be creating for the the end of the semester, what's known as our WOW! ceremony. We're going to do this by watching a short video that introduces to you all what your projects will be.*

FLL Video

As you watch the video, I want you listen and watch out very carefully for answers to these questions:

1) *What excites me the most about creating a robot for this competition?*
2) *What did I see in the video that looks like something I'm especially interested in doing?*

At the conclusion of the video, the teacher should review the answers to the prompted questions. Allow students to volunteer. (approximately 5 minutes.)

Transition: *Now that we have more of an understanding of what we'll be doing, let's talk about what it's going to take for us to get there. It sounds like you all are going to get a lot out of this apprenticeship, and I am just excited to help you all do many of those things you mentioned. I want to take some time to tell you, specifically, what the apprenticeship and WOW! are going to involve, and what we have to do to get there....*

(Note: Another variation of an introduction is to have 3-4 robot models to quickly demonstrate around the room. After you all demonstrate their features, you might say to them, "By the end of 10 weeks, you will use all of your new knowledge to create one of these!" This is a good way to lead into a discussion of the specifics regarding the WOW! Presentation")

Student Action

Students will actively discuss with teacher answers to the provided questions.

Students will participate in Starburst game (or any other opening ritual).

Students will actively watch the video, as evidenced by direction of eyes and minimal distracting behavior.

Modeling - 15 minutes

At this time, the teacher should discuss with the students what the WOW! is going to be. They should use the information on the unit plan as a guide to help you talk through the main points of what students will be expected to do for the WOW! and the major steps they will be taking to get there.

The last part of this discussion should be the "ground rules" or "class expectations." Be sure to emphasize that these will be important for successfully completing the final product and presentation.

Oral Assessment: *Just to make sure you all are on the same page, let's do a quick review.*

At this time, ask questions from your pre-developed list to ensure that students understand important points surrounding class expectations and the WOW!. You may choose to call on students at random or select volunteers.

Transition: *Now that we all understand what the expectations are, let's take our first step. What does FLL expect from us? What kind of robot do they want us to design, and what is it going to take from us, in terms of team work, creativity, and hard work?*

Student Action

During this time, students will be either actively listening (eyes on speaker) or answering the questions provided, as called upon.

"Scaffolding" - 20 minutes

FLL Format and Team Roles

Lecture: The teacher should use the following link to read and be able to simply explain what the FLL competition is essentially about. A major focus on this discussion should be the role of programming for robotics, and the different team roles necessary for project completion.

http://www.firstlegoleague.org/what-is-fll/default.aspx?id=164

After giving the description of the different team roles, have students fill out the team role ballot.

Note: As students complete the ballot, it might be a good idea to repeat several times what each role is (and various examples) so that teacher knows that students really understand what each role encompasses.

Transition: *When we meet again next week, I will let you know what the outcome was. You will know then what team role you will be serving. Until then, let's wrap up for the day by briefly reviewing our WOW! schedule again and doing a quick assessment.*

Student Action

During this time, students will be either actively listening (eyes on speaker) or answering the questions provided, as called upon.

Students will be select and rate the team roles for which they are most interested in serving for the duration of the apprenticeship.

Connection to WOW! and Assessment - 10 minutes

Connection to WOW! - *Everyday, at the end of the day, I am going to take a few minutes to remind us of how what we did today connects our ultimate WOW! For today, you all you were introduced to the FLL challenge and became familiar with what the expectations will be of you to complete the challenge. We also discussed the importance of teamwork before discussing the role you saw yourself playing in designing a robot. You will understand each lesson just how important teamwork will be to successfully designing a robot and completing an accompanying research project. In fact, we will be doing a teambuilding activity for the next few sessions to strengthen and practice our teamwork skills. Finally, we discussed the basic expectations for this apprenticeship, expectations that you cannot forget! Speaking of which, we're going to end class today with a quick assessment to see how much you remembered and learned from our activities today.*

10 minutes - Informal Assessment:

Using your pre-developed list of questions about expectations and team member roles and the FLL challenge, assess and clarify students' mastery of today's objectives. You can do this in different ways. For example:

1. Give each student a note card or other half sheets of paper. Ask the question, and they answer these silently. Take up the half-sheets at the end of the session and gauge how well students answered the questions. Is there anything you might need to clarify at the next session?
2. Cold-call. Ask a question, wait for about 3-4 seconds, and randomly call on a student until most of the students have been called upon. If a student does not get one correct, ask him/her to tell you what they do know about expectations or team member roles. Don't let them get away with "I don't know."

Student Action

Students should pay close attention to teacher as expectations for WOW! Product is explained.

Students will actively write down/discuss with teacher answers to the prompted questions as a form of review.

Name ________________________

- Rate each role: 1- not interested 10- very interested

Robotics Programmer 1 2 3 4 5 6 7 8 9 10

Robot Design 1 2 3 4 5 6 7 8 9 10

Research Specialist 1 2 3 4 5 6 7 8 9 10

Robotics I - Lesson 2

In this lesson, students discuss the role of teamwork to the project completion. Students are then divided into research and programming teams. While some will be introduced to - and practice – programming, others will brainstorm ideas for the research component of the project (based on their analysis of the competition rubric.)

Objectives

- **Explain expectations** of the FLL Research Project Challenge- and the **major aspect**s that will be used to judge its success (rubric.)
- **Apply** learned basic knowledge of robots/NXT programming by **successfully operating** robots/performing basic computer programming.
- **Define teamwork** and **explain its connection** to completion of WOW! product.

Lesson Snapshot:

1. Hook/Introduction (What can robots do?)
2. Teamwork Discussion & Team Divisions
3. Research Team (Rubric and Successful Examples) Design/Programming Team (Programming Tutorial)
4. Assessment and WOW! Connection

Vision for *Student* Mastery:

Various oral assessments will be given throughout the lesson as consistent "check points" for understanding. At the end of the lesson, students will be given the opportunity to share knowledge of concepts they learned in their respective teams with the rest of the class. Other informal assessments will include the successful practice programming activities completed by students on the programming team. The research teams' ideas about research topics should also be assessed according to how well their ideas align with the criteria of the analyzed rubric.

Materials and Pre-Planning

1. ______ # of computers, as needed for each student (w/ headphones and internet connection and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Teamwork Visual (Visual that represents teamwork)
5. Develop a list of 10-12 questions regarding your specific classroom expectations. These will be used as an informal assessment at the end of the lesson.
6. FLL online Video (research examples) and accompanying technology to play it.
7. Access to file storage and/or printing for data collection (research team)
8. FLL Challenge Information (Hard copy printed out)
9. Competition Mat- Purchased through USFIRST.org
10. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
11. Extra Lego pieces for barriers on the competition mat

CITIZEN SCHOOLS

CSITS Standards

CS.CSITS.2

Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.

CS.CSITS.3

"I Can" Skills:

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.

b. I can **collaborate with other team members** to complete computer science projects.

c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

Connection to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

WOW! Scaffolding

Students will be divided into teams for the competition. The research team will take a more detailed look at the challenge (WOW!) expectations (via the competition rubric). The design team will begin the design process for the robots, while the programming team will begin practicing basic programming based on the challenge problem presented.

The Hook/Introduction - 15 minutes

Hold up a large picture of the robot below (or distribute individual copies.) Note: You may also choose your own pictures or actual physical examples of robots and perform the same hook activity to engage students at the beginning of the lesson.

Ask: *Why or why not do you think this counts as a robot?*
If so, what do you think is its function?

Teacher should facilitate students' various responses for 2-3 minutes. After this time, teacher should inform students of whether or not object is a robot and what its specific function is.

← this robot vacuums

Transition: *As we'll learn, robots can look like many different things and can perform many different functions. This is what this apprenticeship is all about. You all, as a team, will be designing your own unique robots with its own special functions to present for your WOW! product and to participate in the FLL competition.*

With that, let's review the class expectations and discuss how today's objectives are going to get you to that point.

There are many different ways to creatively review these.

- You can quickly divide students into 2 teams of 4 and have a quick quiz game using 6-7 general statements regarding classroom expectations.
- You can have each student "stand" if they think a given statement is true about discussed classroom expectations or some other quirky action if they think it's false.

Teacher should inform students of today's objectives.

By the time you leave class today, you all will know how to

- *Explain expectations of the FLL Research Project Challenge- and the* ***major aspect****s that will be used to judge its success (rubric.)*
- *Apply learned basic knowledge of robots/NXT programming by successfully operating robots/performing basic computer programming.*
- *Define teamwork and explain its connection to completion of WOW! product.*

Transition: *We're going to tackle this last objective first by doing a collective brainstorm of what we mean when we say "teamwork."*

Student Action

After analyzing the photo, students will actively discuss with teacher answers to the prompted questions.

To review class expectations and team roles, students will follow the directions provided by the teacher to complete the selected activity (dependent on choice of teacher.)

Students will listen carefully as today's objectives are explained.

Modeling - 15 minutes

Solicit 3-4 responses to the following question:

a. Think back to when you have been part of a successful team (sports, group projects). What made your team successful? Student responses.

b. Using these examples, what do you think "teamwork" means? Student responses.

c. In what ways do you think this definition for "teamwork" will be important in this apprenticeship? Student responses.

Student Action

Students will volunteer responses to the prompted questions or listen attentively while other students do so.

Modeling (Cont'd.)
You can see this idea of teamwork represented in the visual I brought for you all today…
Teacher should display and discuss selected visuals with students.

Transition: *With this in mind, I am now going to announce your teams and the roles that each student will have on that team.* ***But first remind me, what are the three different roles on a team? What is the responsibility of each role?*** Student responses.

5 minutes - Announce teams and student roles.

As you call student names, have them get up and move to their team location.

Transition: Have team leader take the research team and the volunteer take the design and programming team to designated locations.

Student Action

Students will listen for the team role to which they have been designated. Students will then go to the location designated for their respective team roles.

"Scaffolding" /"Coaching" - 50 minutes

(Split time between Design Team & Research Team)

A. Design & Programming Team:

Introduction: *While the research time is getting familiar with completing the research project to accompany the designed robot, you all will be working on actually doing the programming. To do that, we're going to start with a quick video tutorial about the basic facts we need to know to get started, and then we are going to practice these concepts until I know you*

1. Watch tutorial **Ortop.org/NXT_Tutorial/ (30 minutes)**
2. Students will then practice programming concepts learned in the video. (20 minutes)
   Students should repeat at least 4 times so that students master knowledge of these 4 basic programming tips.

B. Research Team:

Introduction: *As you all know, the research project is a major component of the FLL competition. For this reason, we all have to figure out what makes a good research project. What are the judges looking for in quality research projects? To answer this, we're going to look at a few examples of research projects and then discuss some possible ideas for our own research project.*

1. Watch video of **research examples** USFIRST.org (10 minutes)
2. Read the official FLL research challenge & discuss the rubric (10 minutes)
3. Get into groups and brainstorm ideas for research projects (20 minutes)

Note: Teacher should record the ideas for later use.

Student Action

Students in the design and programming team will actively watch the tutorial on robotics programming and design, then they will practice the programming concepts demonstrated in the video.

Students in the research team will watch video clips of sample research projects. They will then closely analyze the rubric to determine the more specific expectations of a quality research project. Finally, students in the research team will collectively brainstorm ideas for a research project to complete.

Connection to WOW! and Assessment - 15 minutes

Connection to WOW! - *So how does what we did today connect with our overall goal for the WOW! presentation? The first important thing we did was that we divided ourselves up according to the team roles that each one of us will be fulfilling. It will be really important for us to take our new team roles successfully. As we have learned, everyone doing their part and taking their team role seriously will be the only way we have a great WOW! product. Our programming team got their first taste of programming and they did a wonderful job of practicing those concepts. On the other end, our research team began brainstorming some ideas for the research project that we will begin collecting data for on next week.*

Assessment

In fact, the way that we are going to end class today is by having a representative from programming team share the ideas they came up with to rest of class. After they have done so, a representative from the programming team will share two things that the team members learned about programming today that they did not know before. Particularly, we want to know what role it plays in robotics? Why is programming necessary? Finally, we're going to have a representative from the class in general explain to us what they learned about the role of teamwork for today. Who are going to be my volunteers?

As students share knowledge, teacher should clarify student understanding as necessary.

Student Action

Students will listen attentively as connections to ultimate WOW! product is explained.

Students will either volunteer to share knowledge as prompted or will otherwise listen attentively as other students do so.

Robotics I - Lesson 3

In this lesson, the research team will continue collecting relevant data will potentially inform a research project. The design team will build the robotics obstacle course and the programming team will continue practicing basic programming in preparation for the robotics programming.

Objectives

-Utilize understanding of teamwork to successfully complete a team-building activity.
-Collect and organize research data *relevant* to problem as presented by competition challenge (research team)
-Build the robotics obstacle course (design team)
-Analyze the robotics course to assess implications for robotics design (design team)
-Utilize knowledge of programming to program basic robotics operations (programming team)

Lesson Snapshot:

1. Hook: Robot teaser ritual
2. Team Building Activity ("The Body")
3. Work Session (Research, Design, and Programming)
4. Assessment and WOW! Connection

Vision for *Student* Mastery:

To demonstrate mastery of objectives, students in the research team s will need to have researched, identified, and analyzed a reasonable number of sources to use and be able to make connections between these sources and the problem/solution the team is considering, Students in the programming and design teams will need to be able to successfully utilize their knowledge of programming to program basic robotic operations, build the robotics course, and analyze the robotics course to assess implications for robotics design. As a reach, students in these teams will attempt to program and design the easiest robotics task.

Materials and Pre-Planning

1. ______ # of computers, as needed for each student (w/ Internet connection and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Small random objects to be used for Human Robot game (see below)
5. Access to file storage and/or printing for data collection (research team)
6. Competition Mat- Purchased through USFIRST.org
7. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
8. Extra Lego pieces for barriers on the competition mat.

CSITS Standards

CS.CSITS.2
Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
b. . I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols**.**

CS.CSITS.3

Citizen schools students will <u>collaborate and effectively work in teams</u> to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
b. I can **collaborate with other team members** to complete computer science projects.
c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

Connection to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

WOW! Scaffolding

With a focus on the WOW! product and presentation, the design team will work towards a better understanding of the missions on Robotics Course while the research team will decide on a research project to pursue. The design team will choose a robot design best suited for the course objectives. Students will also begin a series of team-building activities as teamwork will be a major judging factor for the challenge (WOW!).

The Hook/Introduction - 15 minutes

Hold up a large picture of the robot below (or distribute individual copies.) Note: You may also choose your own pictures or actual physical examples of robots and perform the same hook activity to engage students at the beginning of the lesson.

Ask: *Why or why not do you think this counts as a robot?*
If so, what do you think is its function?

Teacher should facilitate students' various responses for 2-3 minutes. After this time, teacher should inform students of whether or not object is a robot and what its specific function is.

What is the function of the robot?

← This robot performs surgery.

Transition: *In building your own robots, remember that teamwork will still be incredibly important. Because of this, before we even get to robots today, we are going to do a quick team-building activity to demonstrate my point.*

Student Action

After analyzing the photo, students will actively discuss with teacher answers to the prompted questions.

Modeling/Scaffolding/Coaching - 15 minutes

II. Team Building Activity

- The students will divide into their teams (Research and Programming combined for two different teams)

The teacher should explain the instructions for the game:

Each team will have someone play the The Mouth, The Eyes, and the Body.

The game: *The objective of the game is to retrieve the object placed by the team leader.*

1. ***The Body:*** *This person will be blindfolded: This student will try to pick up the object by listening to the mouth.*
2. ***The Mouth:*** *This student may talk but cannot look at the direction of the body. This student will relay directions to the body.*
3. ***The eyes:*** *The rest of the students will relay* ***non-verbal*** *messages to the mouth. The eyes can see the body but they cannot talk.*

Once preparation has been made (blindfold, etc.), allow students 10 minutes to search for the designated object in their teams.

Debrief questions (5 minutes)

1. ***For the Mouth:*** *Was it difficult having 4- 5 students give you direction? What could have helped the confusion?*
2. ***The Eyes:*** *Did you come up with a strategy to communicate better with the mouth? Did you feel that the mouth was listening?*
3. ***The Body:*** *were the directions given by mouth clear?*

*** This activity is about communicating with each other to achieve the same goal. Teamwork is about communicating effectively and listening to each other.**

Student Action

Students will listen closely to the directions of the team building activity.

Students will actively participate in the team building activity in one of the designated roles.

Students will either volunteer responses to the prompted debrief questions or listen attentively as other students do so.

"Coaching" - 55 minutes

Work Session: Check the Game Rulings on the *FIRST* website (usfirst.org/fll)

Research Team:
The students should share research to date, select a problem to focus on, and begin researching the problem and existing solutions. The students should share team member research on the selected problem, existing solutions to that problem, and information gathered from different experts (e.g., online, personal interviews). Using this information, students should refine the team's identified problem and brainstorm innovative solutions. The students should continue researching existing solutions and consider talking to experts in the areas to advance their understanding.

Robot Design and Programming: The students should build the mission models and set up the practice field. The students should review the missions and rules and brainstorm possible mission strategies and associated robot designs. The students should also experiment with chassis designs and simple programming tasks. If time permits, the students should design and program the robot to perform the two missions that the team considers the easiest. The students in this team should also consider robot designs and strategies for expansion to other missions. Finally, students (and teacher) should be sure to save copies and back-up programs.

Student Action

Students in the research team will actively do library or online research, guided by teachers. Students will collaborate (feedback and comments) with other team members to successfully identify a problem and potential innovative solutions.

Students in the robot design and programming teams will construct the obstacle course for the robots according to FLL challenge rules. After experimenting with basic programming tasks, students will then attempt to design and program two robotic missions that might be considered the easiest.

Coaching (cont'd.)

Build/Program Robots

Students begin work in respective teams. As they do so, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots and research project will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking students in the programming and designing group to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Transition: *Nice work guys! Let's go ahead and wrap it up for the day.*

Connection to Wow! and Assessment - 5 minutes

Connection to WOW! *- So where we are on our way to the WOW! product? We made some great progress today. The design team now has a better understanding of the missions on Robotics Course while the research team will decide on a research project to pursue. The design team also began considering a robot design best suited for the course objectives. Finally, we were able to successfully complete another team-building activity. Because all of these factors will be major considerations for how successful our WOW! is, it is great that we were able to get these things completed! Let us keep the momentum going!*

Assessment: For the research team, as the objectives of the day are to collect and organize relevant research data, assessment will mostly be informally determining how well students in the research team executed this task. The teachers might want to consider the following: Were they able to find a reasonable number of sources to use? Were students able to make connections between these sources and the problem/solution the team is considering?

For the robotics and design team, an informal assessment will be to determine the extent to which students were able to successfully utilize their knowledge of programming to program basic robotic operations, build the robotics course, and analyze the robotics course to assess implications for robotics design.

Student Action

Students should pay close attention to teacher as expectations for WOW! Product is explained.

Robotics I - Lesson 4

Students in the research team draw conclusions from research data collected thus far and begin designing presentation boards. Students of the design team will finalize the robotics design, while students of the programming team will practice program operations using the FLL competition mat for the firs time.

Objectives

-Draw conclusions from collected research data as they inform possible solutions to competition challenge
to robotics solutions (research team)
-
Design presentation boards (research team)

Complete robotic design (design team)

Perform program operations using the FIRST competition mat (programming team)

Evaluate the impact of positive team encouragement on individual performance

CSITS Standards

CS.CSITS.2
Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
b. . I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.

CS.CSITS.3

Citizen schools students will <u>collaborate and effectively work in teams</u> to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
b. I can **collaborate with other team members** to complete computer science projects.
c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

Lesson Snapshot:

1. Hook (Robot operation ritual)
2. Teamwork and positive language activity
3. Research, Design, and Programming Team (Working Sessions)
4. WOW! Connection and Assessment

Connection to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

Vision for *Student* Mastery:

To demonstrate mastery of objectives, students in the research teams will need to have drawn relevant conclusions from collected research data as they inform possible solutions to competition challenge. Students in this team will also need to have been able to work collaboratively to successfully begin designing the presentation board. Students in the programming and design teams will need to be able to successfully apply even more knowledge of programming to perform basic operations using the programming mat for the first time. The robotic design will also need to be collaboratively discussed and finalized by the design team.

Materials and Pre-Planning

1. ______ # of computers, as needed for each student (w/ Internet connection and installed NXT software.)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. A heavy school textbook
5. Stopwatch
6. Access to file storage and/or printing for data collection (research team)
7. Presentation boards for research teams (See example research projects online for First Lego League)
8. Presentation design materials for research teams (See example of research projects online for First Lego League).
9. Competition Mat- Purchased through USFIRST.org
10. 10. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
11. Extra Lego pieces for barriers on the competition mat.

WOW! Scaffolding

As the mid-point of the challenge (WOW!) approaches, students in the research team will draw conclusions from data collected (and decide on a research strategy), while students of the design team will finalize the robot design. Programming team students will continue to practice basic programming skills, this time using the challenge competition mat for the first time.

The Hook/Introduction - 10 minutes

Robot Ritual: What is the robot's function?

Hold up a large picture of the robot below (or distribute individual copies.) Note: You may also choose your own pictures or actual physical examples of robots and perform the same hook activity to engage students at the beginning of the lesson.

Ask: *Why or why not do you think this counts as a robot? If so, what do you think is its function?*

Teacher should facilitate students' various responses for 2-3 minutes. After this time, teacher should inform students of whether or not object is a robot and what its specific function is.

What is the function of the robot?


← U.S Army robot to diffuse bombs.

- Take 3-5 minutes to review agenda, learning objectives and class agreements.

Transition: *Just like the last session, before we even get back to designing your own robots today, we are going to do a quick team-building activity to demonstrate my point.*

Student Action

After analyzing the photo, students will actively discuss with teacher answers to the prompted questions.

Modeling/Scaffolding/Coaching - 15 minutes

II. Teamwork and positive language activity: (15 minutes)
Explain the directions of the activity (not the purpose!), and proceed by selecting a volunteer.

Ask for one student to participate and one student to keep time.
<u>Trial 1</u>
Have one volunteer hold a textbook out in front of their face. This student will be timed to how long he/she can hold the textbook Instruct the class to keep quiet. Stop the clock when the student drops the book.

<u>Trial 2</u>
Have the same student complete the same task but this time instruct the class cheer the student on. **The student should beat his/her first time trial. *The key message is if we use positive language and encourage each other, we will be much more productive and successful in our project.***

Student Action

During the activity, one student will volunteer to participate in the activity, one will volunteer to keep time, and the other students will be cheering for the student throughout the process.

III. Work Time (60 minutes)

a. **Research Team**: - Students should collect more data if necessary and begin to draw conclusions from data. Using their research of possible solutions, students should brainstorm possible solutions and decide on 2-3 viable options. After this is done, students in research team should begin making presentation boards (drawing on understanding of rubric and analysis of research presentations previously submitted for the FLL challenge.)

b. **Design team:** The design team should work on and finalize the robot design according to the challenge rules (usfirst.org/fll, while the programming team will practice programming on the competition mat.

Build/Program Robots

Students begin work in respective teams. As they do so, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots and research project will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking students in the programming and designing group to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Transition: *Nice work guys! Let's go ahead and wrap it up for the day.*

Student Action

Students in the research team will discuss with each other to draw conclusions from the collected data and finalize the problem and solution they will address (with guidance from the teacher). Students will then begin design process of presentation boards based on their understanding of the FLL research presentation rubric.

Students in the programming and design team will discuss with each other to finalize the robotic design. Students will also continue practice programming operations using the competition mat.

Connection to Wow! and Assessment - 5 minutes

Connection to WOW! *We are rapidly approaching the halfway point of the apprenticeship guys! With that in mind, our research team was able to begin the designing of the presentation boards, while our remaining teams got to practice using the challenge competition mat for the first time. We're well on our way!*

Assessment: Informal assessments of each team should be made according to the following criteria:

Research team: At the conclusion of today's work session, top what extent were students able to draw relevant conclusions from collected research data as they inform possible solutions to competition challenge? Were they able to work collaboratively to successfully begin designing the presentation board?

Programming and Design Team: At the conclusion of today's work session, were teachers able to determine that students were able to apply even more knowledge of programming to perform basic operations using the programming mat? Was the final robotic design collaboratively discussed and finalized by the design team?

Student Action

Students should pay close attention to teacher as expectations for WOW! Product is explained.

Robotics I - Lesson 5

Students will continue to work on their respective teams to complete the components of the FIRST challenge. The research team will incorporate visuals onto the research board, and the programming team will practice operations using the mat. Students will also hear about the educational and career paths of professionals involved in programming and/or robotics.

Objectives

-Create relevant, organized, and creative props and visuals to include on research presentation board (research team)

-Design the style and anticipated functions of the team robot (design team)

- Perform program operations using the FIRST competition mat (programming team)

-Explain the educational and career paths of volunteers who have robotics or programming-based careers.

Lesson Snapshot:

1. Hook (Robot operations ritual)
2. Robotics Careers (Volunteers presentation)
3. Programming, Design, and Research Work Sessions
4. Assessment and WOW! Connections

Vision for *Student* Mastery:

To demonstrate mastery of objectives, students in the research teams will need to be able to create relevant, organized, and creative props and visuals to include on research presentation board, while students in the programming and design team will need to be able to confirm that the robot design aligns well with the obstacles presented by the competition mat and show increased skill in programming and operating robots for success on the challenge competition mat.

Materials and Pre-Planning

1. ______ # of computers, as needed for each student (w/ Internet connection and NXT software installed)

2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Access to file storage and/or printing for data collection (research team)
5. Presentation boards for research teams (See example research projects online for First Lego League)
6. Presentation design materials for research teams (See example of research projects online for First Lego League)
7. Competition Mat- Purchased through USFIRST.org
8. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
9. Extra Lego pieces for barriers on the competition mat.
10. Competition permission slips/agreements. (check USFIRST.org)

CSITS Standards

CS.CSITS.2
Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
b. . I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.

CS.CSITS.3

Citizen schools students will <u>collaborate and effectively work in teams</u> to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
b. I can **collaborate with other team members** to complete computer science projects.
c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

CS.CSITS.5
Citizen schools students will compare and contrast the ways in which computing enables innovation in other fields.

a. I can **make comparisons between skills learned and identified careers in computing**, including - but not limited to - information technology specialist, Web page designer, systems analyst, programmer, and CIO.

Connection to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

WOW! Scaffolding

As the midpoint of the apprenticeship, students in the research team will finalize the solution they developed based on data summary (corresponding to FLL challenge.) The design & programming team collaborate to confirm that the robot design developed is the best design for the course. This is important as robot navigation of the obstacle course is a major component of the FLL challenge (and WOW!).

The Hook/Introduction - 10 minutes

Robot Ritual: What is the robot's function?

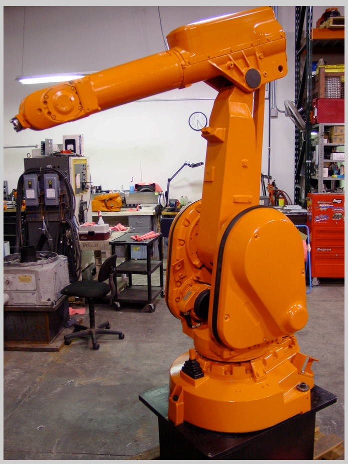
Hold up a large picture of the robot below (or distribute individual copies.) Note: You may also choose your own pictures or actual physical examples of robots and perform the same hook activity to engage students at the beginning of the lesson.

Ask: *Why or why not do you think this counts as a robot? If so, what do you think is its function?*

Teacher should facilitate students' various responses for 2-3 minutes. After this time, teacher should inform students of whether or not object is a robot and what its specific function is.

What is the function of the robot?

I. Robot Ritual & Agreements



← Robot arm used to build cars

Review Agreements according to competition requirements (e.g., parent signatures for participation.)

Transition: *We've now reached the midpoint of the apprenticeship, and it is important for you all to know how the skills you are using and learning translate to a career building or studying robotics. To do that, we have some volunteers who will share with us today about their careers in robotics. Pay close attention, as I want you to listen closely for how what we have been doing these past five weeks fit with what people who study and build robots every day do!*

Student Action

After analyzing the photo, students will actively discuss with teacher answers to the prompted questions.

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"Scaffolding" - 15 minutes

Career and Education Paths: This session will largely depend on the planning and resources of the teacher. In any case, volunteers or a career/education connections activity should address the following:

1. Where they went to school?
2. What kind of student they were in middle school, & high school?
3. Major and masters?
4. Why they chose that career path to do robotics?
5. Where they work?
6. Do they like their jobs? What is the best part of their work?
7. Role of teamwork in studying robotics?

- **Give 5 -7 minutes for students to ask questions.**

Transition: *I hope that hearing the stories of these volunteers has inspired you and helped you realize that the things you are learning how to do in this apprenticeship has strong connections to people who have careers in robotics. You could easily be one of those people by working hard enough! Speaking of which, it is now time for us to return to work on our robots and presentations for the WOW! Off to your teams!*

Student Action

Students will listen attentively to volunteers as they discuss their educational and career paths in robotics.

Work Time

a. Research Team: Students in this team should finish preparing materials and plans for sharing the team's findings (presentation). The members should also do any remaining necessary research to fill in gaps and work on the visual aids needed for sharing their findings.

b. Design and programming team (Combined from here until conclusion of apprenticeship): - Between these two teams, the robot design will need to be finalized. The combined team should ensure that all intended scoring strategies are legal and worth points. Remember to update copies of the missions and rules documents as they are updated in the Game Rulings.

Build/Program Robots

Students begin work in respective teams. As they do so, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots and research project will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking students in the programming and designing group to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Transition: *Great work! Let's reel it in for the day!*

Student Action

Students in the research team will work collaboratively to continue research as needed and design visual aids needed for presentation.

Students in the designing and programming team will discuss and confirm strategies for gaining competition points through robotic operations. They will also continue programming as needed.

Connection to WOW! and Assessment - 5 minutes

Connection to WOW*! - We have halfway completed the apprenticeship guys! Our research team has finalized the solution they developed based on their research data summary. Our programming and design teams have confirmed that the robot design to be developed is the best design for the obstacle course. All of these are very important steps as we make our way towards a great WOW! product!*

Assessment:

Today, we were able to listen to a few volunteers about their career and educational paths that resulted in them working with robots. Because I have a feeling we are going to have some students in here do the same, I want us to review some of the important things we heard from those volunteers today. Let's discuss a few questions:

1. Based on what we heard, what are some of the educational experiences you will probably need to have a career in robotics?
2. What kind of students were they most likely when they were in middle school?
3. What kinds of skills did their jobs require?
4. What role did they say teamwork played in doing their job successfully?
5. Any other appropriate question, as determined by the teachers.

Informal assessments of each team should also be made according to the following criteria:

Research Team: Were they able to create relevant, organized, and creative props and visuals to include on research presentation board?

Programming and Design Team: Were students able to successfully confirm that the robot design aligns well with the obstacles presented by the competition mat? What skills did they use to do this?

Student Action

Students should pay close attention to teacher as expectations for WOW! Product is explained.

Students should discuss (and/or listen attentively to) college/ career questions as prompted by teacher.

Robotics I - Lesson 6

The lesson will continue the discussion of the educational and career connections to the computer programming and robotics by focusing on opportunities for pursuing robotics in high school. As an important step, the programming team will complete the first two programming tasks according to the requirements of the competition mat.

Objectives

Summarize opportunities available for pursuing interest in robotics at high school level.

Create relevant and creative visuals to incorporate into research presentation (research team)

Complete necessary program tasks (1 and 2) as required by competition mat.

Lesson Snapshot:

1. Hook (Robot operations ritual)
2. Pursuing robotics in high school
3. Programming/Design and research work sessions
4. WOW! Connection and Assessment

Vision for *Student* Mastery:

To demonstrate mastery of objectives, students in the research teams will need to be able to create relevant, organized, and creative props and visuals to include in *delivery* of presentation, while students in the programming and design team will need to completethe necessary program tasks as required by the competition mat (task 1 and 2).

Materials and Pre-Planning

1. ______ # of computers, as needed for each student (w/ Internet connection and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Access to file storage and/or printing for data collection (research team)
5. Presentation boards for research teams (See example research projects online for First Lego League)
6. Presentation design materials for research teams (See example of research projects online for First Lego League)
7. Researched high school robotics programs and invited guest high school speaker for students.
8. Competition Mat- Purchased through USFIRST.org
9. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
10. Extra Lego pieces for barriers on the competition mat.

CSITS Standards

CS.CSITS.2

Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
b. . I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.

CS.CSITS.3

Citizen schools students will <u>collaborate and effectively work in teams</u> to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
b. I can **collaborate with other team members** to complete computer science projects.
c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

CS.CSITS.5
Citizen schools students will compare and contrast the ways in which computing enables innovation in other fields.

a. I can **make comparisons between skills learned and identified careers in computing**, including - but not limited to - information technology specialist, Web page designer, systems analyst, programmer, and CIO.

Connections to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

WOW! Scaffolding

As part of the development of the final challenge (WOW!) products, the research team will type and create visuals for the presentation board. The programming sub-teams will work on completing the first two major tasks that the robot will need to be able to perform for the FLL challenge (WOW!) .

The Hook/Introduction - 15 minutes

Robot Ritual: What is the robot's function?

Hold up a large picture of the robot below (or distribute individual copies.) Note: You may also choose your own pictures or actual physical examples of robots and perform the same hook activity to engage students at the beginning of the lesson.

Ask: *Why or why not do you think this counts as a robot? If so, what do you think is its function?*

Teacher should facilitate students' various responses for 2-3 minutes. After this time, teacher should inform students of whether or not object is a robot and what its specific function is.

What is the function of the robot?

I. Robot Ritual & Agenda

← This robot can assist humans with daily tasks

Transition: *Again, it is important for you all to know how the skills you are using and learning translate to a career building or studying robotics. Similar to what we did on the last session, we have some volunteers who will share with us today not about their careers in robotics, YET, but more about some of the opportunities available pursue your interest in robots at the high school level.*

Student Action

After analyzing the photo, students will actively discuss with teacher answers to the prompted questions.

Scaffolding/Coaching - 20 minutes

Opportunities to Pursue Robotics at the High School Level.

This part of the lesson is designed to introduce to students ways that they can pursue their interest in robots at the high school level. The nature of the presentation will largely depend on arrangements made by the teacher for volunteers to come and visit the class.

Transition: *Let's thank our guests! With only four more weeks until we have to submit our own robot and presentations, let's get to work!*

Student Action

Students should listen attentively to presentation of high school students explaining opportunities for pursuing interest in robotics at that level.

"Coaching" - 60 minutes

Work Time

a. **Research Team:** The research team should plan to finish the visuals to be included on the presentation. With the guidance of a teacher, they should come up with a way to creatively present the team's project in a live presentation for the judges. They should then begin creating the presentation materials for the Project presentation.

b. **Programming and Design Team:**
Split into 2 divisions:
Division A: (1) Lead programmer (1-2) Students from design team
Division B: (1) Lead programmer (1-2) Students from design team
Division A will work on program task 1
Division B will work on program task 2
Each task will attempt to gain points from a different starting point in the competition mat.

Build/Program Robots

Students begin work in respective teams. As they do so, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots and research project will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking students in the programming and designing group to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Transition: *With that, let's go ahead and wrap it up for the day!*

Student Action

Students in the research team will work with teammates to conclude the visual designs for the presentation. Students will also begin discussing creative ways to **present** their research findings and solution.

Students in the programming and design team will work on a specific task in respective sub-teams.

Connection to Wow! and Assessment - 15 minutes

Connection to WOW!: *We are certainly on our way to a successful WOW! Based on our progress today, the programming and design team have completed the first two programmed tasks, and the research team is already thinking about how to creatively and effectively present their findings and solutions. Nice work*!

Assessment:

High school is not that far away for a lot of you. According to the presentation from the volunteers we heard today, what are some ways that you all can continue to be involved in robots when you go on to high school?

Students respond.

Informal Assessment: Informal assessments of each team should also be made according to the following criteria:

Research Team: Were they able to create relevant and creative visuals to incorporate into research presentation?

Programming and Design Team: Did they complete necessary program tasks (1 and 2) as required by competition mat?

Student Action

Students should listen carefully as teachers explain the connections between the day's lesson and the ultimate WOW! product.

Students should actively discuss and answer the question posed by the teacher (or listen attentively while other students do so.)

Robotics I - Lessons 7 & 8

These two lessons will provide students opportunities for extensive work sessions for completing their respective parts of the project challenge. By week 8, students will have the research project and robotics design and programmed tasks finalized.

Objectives

-Create a research project and presentation that is creative, entertaining, and is solution-oriented according to FLL challenge (research team)

-Design and program robot to complete at least 4 major tasks. (design and program teams.)

Lesson Snapshot:

Work session as needed.

Materials and Pre-Planning

1. _______ # of computers, as needed for each student (w/ Internet connection and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Access to file storage and/or printing for data collection (research team)
5. Presentation boards for research teams (See example research projects online for First Lego League)
6. Presentation design materials for research teams (See example of research projects online for First Lego League)
7. Competition Mat- Purchased through USFIRST.org
8. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
9. Extra Lego pieces for barriers on the competition mat.

CSITS Standards

CS.CSITS.2

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"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
b. . I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.

CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
b. I can **collaborate with other team members** to complete computer science projects.
c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

Connection to Guiding Questions

In what ways can robots be used to solve certain problems, and what are the limitations of a robot?

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

WOW! Scaffolding

As extensive work sessions for completion of the WOW! product and FLL challenge, students will finish the research posterboards, begin preparing for final presentations (research teams), and complete the last two robotics programming tasks (programming and design teams) according to challenge mission. (Students should also get FLL permission slips signed if they have not yet done so.)

Coaching - 90 minutes

Extensive Work Sessions

Check the Game Rulings on the FIRST website (usfirst.org/fll). By this time in the team probably knows what it wants to achieve and what it is capable of achieving. **Make final goals that are meaningful and realistic.**

Research Team:

Put the finishing touches on the presentation and visual aids. Have members assess whether they include all three steps of their project adequately in their presentation. Rehearse! Use a stopwatch to make sure the team is staying under the five-minute limit. Have members practice setting up and cleaning up without adult assistance; as well as responding to questions.

Session 8:

Fine tune the project presentation to make sure that the team can consistently set up on their own, finish in five minutes, present smoothly, and respond confidently to questions.

- By the end of week 8, all visuals and speeches should be completed.
- Presentations should be practiced and well rehearsed.
- Team Leader please be sure that the presentation is creative, has a solution that addresses the problem and is entertaining.

Programming Team:

Have the members test the robot in different lighting conditions, understand the effects of a battery change and practice changing robot operations. Save copies and back-up programs.

Session 8:

Fine tune the robot's design and programming. Practice changing robot operators.

- By the end of week 8, Division A should have 2 programming task completed and Division B- 2 programming task completed.
- **A total of 4 programming tasks completed.**
- Each task should be practiced and proven effective.
- Save programming tasks onto team robot.

Build/Program Robots

Students begin work in respective teams. As they do so, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots and research project will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking students in the programming and designing group to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Student Action

Students in the research team will finalize the design and presentation of their projects. They will then rehearse the presentation as necessary, paying close attention to effective delivery, creativity, and time limit.

Students in the programming and design team will continue programming to ensure that at least 4 pogramming tasks can be completed by the robot *and* can be consistently achieved by the robot.

Robotics 1 - Lesson 9

Students will add last edits to research project/presentation and robotics design. Students will also begin practicing as a collective group with all other project groups. Special attention will be given to preparing students for the teamwork interview, a major component of the FLL challenge. Students will also get a chance to design team t-shirts.

Objectives

- **Apply their knowledge** of project-based research, robotics design, programming, and teamwork through effective, creative presentations and products (robots) for WOW! ceremony and FLL challenge.

Lesson Snapshot:

1. Teamwork Interview Practice/Preparation
2. Work Sessions (Including practice of presentations and programming tasks.)
3. WOW! Connection and Assessment

Vision for *Student* Mastery:

Whether or not students have mastered the objectives will be evidenced by strong teamwork interviews, effective presentations from the research team, and proven mastery of program tasks according to rehearsals witnessed today. These should be ongoing assessments throughout the lesson.

Materials and Pre-Planning

1. _______ # of computers, as needed for each student (w/ Internet connection
and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Access to file storage and/or printing for data collection (research team)
5. Presentation boards for research teams (See example research projects online for First Lego League)
6. Presentation design materials for research teams (See example of research projects online for First Lego League)
7. Competition Mat- Purchased through USFIRST.org
8. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
9. Extra Lego pieces for barriers on the competition mat.
10. Large writing pad or display board.

CSITS Standards

CS.CSITS.2
Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
e. I can **summarize how to design and operate** a robot, computer game, or other computational artifact that uses functions to solve problems. (WOW!)
f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

CS.CSITS.3
Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.

b. I can **collaborate with other team members** to complete computer science projects.

c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

d. I can **constructively evaluate my and others' performance** in a particular team role.

Connection to Guiding Questions

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

In what ways can robots be used to solve certain problems?

WOW! Scaffolding

Students will use this time for in-depth preparation for the WOW! and FLL challenge. Specifically, the research team will perform detailed rehearsals of presentation, while the programming and designing teams will make the final tweaks to the programming tasks. Rehearsals will also be done as a group after students are oriented in detail to

"Modeling"-"Scaffolding" -"Coaching" - 25 minutes

Teamwork Interview Preparation

- Have each team sit in a circle
- Explain the basic scoring of tournament (5 minutes)
  a. Research presentation (33%)
  b. Programming (33%)
  c. Teamwork Interview (33%)

- Tell students that they've prepared for the first two parts and now they need to prepare for teamwork interview session.
- Tell students that there will be secret judges going around the team tables observing each team. Judges will be looking for positive language and supportive team interactions.

- Tell students that each team will be pulled into a classroom and will be interviewed by judges on how they displayed team work.
- Have students brainstorm ways that they've exhibited teamwork in the past 8 weeks. Write or type their answers on a visual. (10 minutes)
- Practice with students on how they will answer the following questions: (10 minutes)
  1. How was the work divided?
  2. Did adults help you a lot?
  3. Who did most of the work?
  4. How did you display teamwork?
  5. Did you all feel you were part of the team and how?

A visual might also prove to be helpful for this part of the rehearsal. Students may want to record the type of answer they would want to give and use the display board for reference as they rehearse the team interview.

Transition: *Now that you have been introduced to this component of the competition, we are going to rehearse the team interview 2-3 times. We will then break back into teams and continue work sessions.*

Student Action

Students will listen attentively to teacher's explanations of how they will be judged according to teamwork exhibited. They might also ask any clarifying questions.

Students will brainstorm with their teams the answer to the prompted question. They will then practice, with the guidance of a teacher, answering in a coherent and effective manner answers to the challenge questions regarding teamwork.

"Coaching" - 60 minutes

In teams, and under the guidance of a teacher, each team should have 2-3 times to practice answering the questions for the team interview. (20 minutes)

After this is completed, teachers should divide students into research and programming/design teams to continue work as necessary. (40 minutes)

Research Team: Students should practice presentation 2- 3 times. If there is time, they may want to brainstorm team name and design a team logo (dependent on site, resources, time, and teacher discretion).

Programming team: Students will continue practicing their programming tasks. An extension activity might be for them to complete a 5th task if time permits.

Student Action

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They will then practice, with the guidance of a teacher, answering in a coherent and effective manner answers to the challenge questions regarding teamwork.

In the research team, students will rehearse their presentation under the guidance of a teacher.

In the programming team, students will continue practicing their programming tasks (and will add a fifth ask if time permits.

Connection to Wow! and Assessment - 5 minutes

Connection to WOW*!* - *This is it guys! Very similar to this session, next week's session will be spent making any final edits we need to and continuing to rehearse for the competition!* (Rehearsal goals and structures will be at teacher discretion.)

Assessment (Closing Ritual):

Whether or not students have mastered the objectives will be evidenced by strong teamwork interviews, effective presentations from the research team, and proven mastery of program tasks according to rehearsals witnessed today. These should be ongoing assessments throughout the lesson.

Student Action

Students will listen closely as connections to the WOW! product and presentation are made for the day.

Robotics I - Lesson 10

This lesson will be a rehearsal session, as needed, and celebration of team progress.

Objectives

- **Apply their knowledge** of project-based research, robotics design, programming, and teamwork through effective, creative presentations and products (robots) for WOW! ceremony and FLL challenge.

Lesson Snapshot:

1. Rehearsal
2. Tournament Logistics
3. Celebration!

Vision for *Student* Mastery:

Whether or not students have mastered the objectives will be evidenced by strong teamwork interviews, effective presentations from the research team, and proven mastery of program tasks according to rehearsals witnessed today. These should be ongoing assessments throughout the lesson.

Materials and Pre-Planning:

1. _______ # of computers, as needed for each student (w/ Internet connection and NXT software installed)
2. Computer with large display screen to show robot example at beginning of class.
3. Generic practice robot (team leader or volunteer create before class.)
4. Access to file storage and/or printing for data collection (research team)
5. Presentation boards for research teams (See example research projects online for First Lego League)
6. Presentation design materials for research teams (See example of research projects online for First Lego League)
7. Competition Mat- Purchased through USFIRST.org
8. Lego Mindstorms NXT 2.0- (1 kit for every 6 students)
9. Extra Lego pieces for barriers on the competition mat.
10. Snacks and drinks for celebration!

CSITS Standards

CS.CSITS.2

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"I Can" Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
e. I can **summarize how to design and operate** a robot, computer game, or other computational artifact that uses functions to solve problems. (WOW!)
f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

"I Can" Skills:

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.

b. I can **collaborate with other team members** to complete computer science projects.

c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.

d. I can **constructively evaluate my and others' performance** in a particular team role.

Connection to Guiding Questions

What role does team work play in programming and constructing a robot?

How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?

In what ways can robots be used to solve certain problems?

Rehearsal:

Instead of a formal lesson to implement, teachers are advised to use this session in whatever ways necessary to ensure sufficient WOW! preparation. Some things to keep in mind:

1. Part of the preparation for the WOW! ceremony will need to include setting up the obstacles for each team's robot. For example, if a robot will be following a line as its feature, lines of painters tape should be placed on poster board for line followers. (Note: These poster boards could be tiled so they could be interchangeable and create a variety of courses, by reordering the tiles.). If a robot will be interacting with a ball, balls should be placed in necessary places.

2. Teachers and students should make last minute changes and confirmations for programming, enhancement features, etc. (Is every feature of each robot working properly?)

3. Teachers should be sure to test students' understanding and ability to explain how they built their robot (building instructions), what its specific features include, how it was programmed (sequencing, looping, conditionals, role of algorithms), and be able to effectively demonstrate what their robot can do *and* the significance of its action (For example, what is scientifically allowing it to do what it is doing?.) Students should also practice being adept at answering a range of questions that pertain to these things.

4. Students should have adequate time to present and practice as teams (with their robot) repeatedly (at least three times a team.)

5. All robots and other necessary materials should be properly stored in a safe location until the WOW! ceremony.

Tournament Logistics

1. Share timeline for the tournament. (Coaches' handbook and online information)
2. What to bring and what to expect. (Coaches' handbook and online information)

Celebration

- Provide food and snacks
- Give out team awards
- Acknowledge their hard work and dedication
- Deliver message that no matter what happens in the tournament, this is a big accomplishment.
- Everyone should be proud of themselves!

Below are questions that might be tailored for a Pre/Post-assessment. The language may need to be adjusted for middle school students. The answers to these will largely depend on who teaches the apprenticeship as answers may slightly vary from individual to individual. For this reason, it may be necessary to have teachers answer the questions themselves (to develop the "key") and use their completed questions as a guide for teaching the specific content knowledge throughout the apprenticeship. Furthermore, I limited the questions to 7-10 per apprenticeship to allow teachers the room to add any other questions they may find to be relevant to the content of the apprenticeship (and is invested in teaching students that specific content or skill.)

Y.U.R. Web Design

1. What is an online community?
2. What do good online communities know how to do?
3. Explain the role that "gadgets" play in online communities?
4. Compare and contrast a website and a blog.
5. What is cyberbullying?
6. When is it okay to borrow online information or visuals without permission from the owner?
7. What is the difference between public and private information? Which should never be included on a website?
8. What online tools can be used to design a website?
9. What does it mean to do "web design" as a profession?
10. What educational requirements are there for achieving a career in web design?
11. What does an effective oral presentation about a project look like or entail?

Scalable Game Design

1. Describe a simple way to design a computer game.
2. What is an algorithm? Explain their roles in designing a computer game.
3. How can game design help build knowledge in other subjects, like math, science, and language?
4. What does it mean to do "game design" as a profession?
5. What educational requirements are there for achieving a career in game design?
6. What are the four basic computational thinking patterns for scalable game design?
7. What are the three components of Agentsheets software?
8. How can constructive feedback from colleagues help a person design a computer game?
9. What does an effective oral presentation about a project look like or entail?

Robotics

1. Compare and contrast humans and robots.
2. What makes something a robot?
3. What is an algorithm? Explain their roles in designing a robot.
4. How can robots be used to solve “problems?”
5. What does it mean to be involved in “robotics” as a profession?
6. What educational requirements are there for achieving a career in robotics?
7. Compare and contrast the different team roles necessary for successfully and creatively completing a robotics project.
8. How can one provide constructive feedback to a team member in a robotics project?
9. What does an effective oral presentation about a project look like or entail?

Robotics 1.

1. What is an algorithm? Explain their roles in designing a robot.
2. What does it mean to be involved in “robotics” as a profession?
3. How can robots be used to solve “problems?”
4. What educational requirements are there for achieving a career in robotics?
5. Compare and contrast the different team roles necessary for successfully and creatively completing a robotics project.
6. How can one provide constructive feedback to a team member?
7. What does it mean to successfully work as a team member in designing a robot?
8. What are some possible solutions for the problem, __________ (dependent on FLL challenge)?
9. What does an effective oral presentation about a project look like or entail?

Robotics 101:

Starting a robotics project and the use of LEGO Mindstorms NXT ® Robotics Kits to Facilitate Experiential Learning in Science and Technology

A. M. Habib
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CYFAR 2009

Workshop Overview

- Background
- Technology overview
- Introduction to programming a robot using Mindstorms NXT ®
- Group exercises and programming challenges
- Starting your own robotics club or program
- Wrap up and evaluation

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“It’s learning that is fun.”

-Youth member of FIRST LEGO League robotics team

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One Million New Scientists, One Million New Ideas

- Robotics is an integral part of National 4-H's SET initiative
- National 4-H has recently signed an MOU with FIRST Robotics

+ Excerpts from Interviews of youth participating in Wisconsin's robotics programs

The most important thing I've learned:

- To be a good team - find out what everyone is good at, let them choose and be successful at their skill
- I've learned that the robot must be designed to be versatile and to be able to fix any mistakes, because they *will* happen.
- When you work as a team, you get a lot farther
- I learned social skills and researching skills. And also that working with a team can be a lot of fun.

Some of the most effective ways, in my experience, to getting team together and staying focused are: to set specific goals for the time the team is together and on their own, and to have "report-backs", telling the other team-members what you accomplished and sharing ideas for better ways of getting something done.

All youth interviewed are less than 14 years old

+ Excerpts from Interviews of youth participating in Wisconsin's robotics programs (contd.)

I would join the team next year because it teaches valuable design and presentation skills, teaches participants to work under pressure, and it can be very exciting and is a great way get to know other people.

Q: Do you think because of this class you would be more likely to become an engineer or a scientist?

A: Yeah, I think I will, because it's fun to do and I like doing it.

Well, my computer skills helped me to learn how to write downloads and things better. And I've actually learned how to become a computer designer, where I design things on the computer, which is a good kind of start.

All youth interviewed are less than 14 years old

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Why Study Robotics?

- Robotics is an excellent way to introduce the students to integrated STEM areas (science, technology, engineering, and mathematics)
- Students participating in robotics learn about STEM careers and experience the same activities as professionals solving real-world problems
- Everyone – girls and boys alike – should get a chance to see how much fun it is learning engineering skills this way!

Basic Development Process

- Create a Lego construction with
  - Lego pieces
    - Either traditional bricks or newer Technic parts
  - NXT Micro-controller
- Motors / Lights
  - Robot controlling output
    - Sensors
      - Input from the environment the robot is operating in
  - Create Program on the Computer
  - Download program to the NXT via USB or Bluetooth

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What is LEGO MINDSTORMS™ Robotic Invention System™

Not JUST a Toy

- Design and program real robots
  - Build Lego creations to perform actions
  - Program using a graphical programming language blocks

Technology Overview: Brick & Sensors

NXT Brick: the robot's 'brain"

Light Sensor

Sound Sensor

Touch Sensor

Ultra-sound Sensor

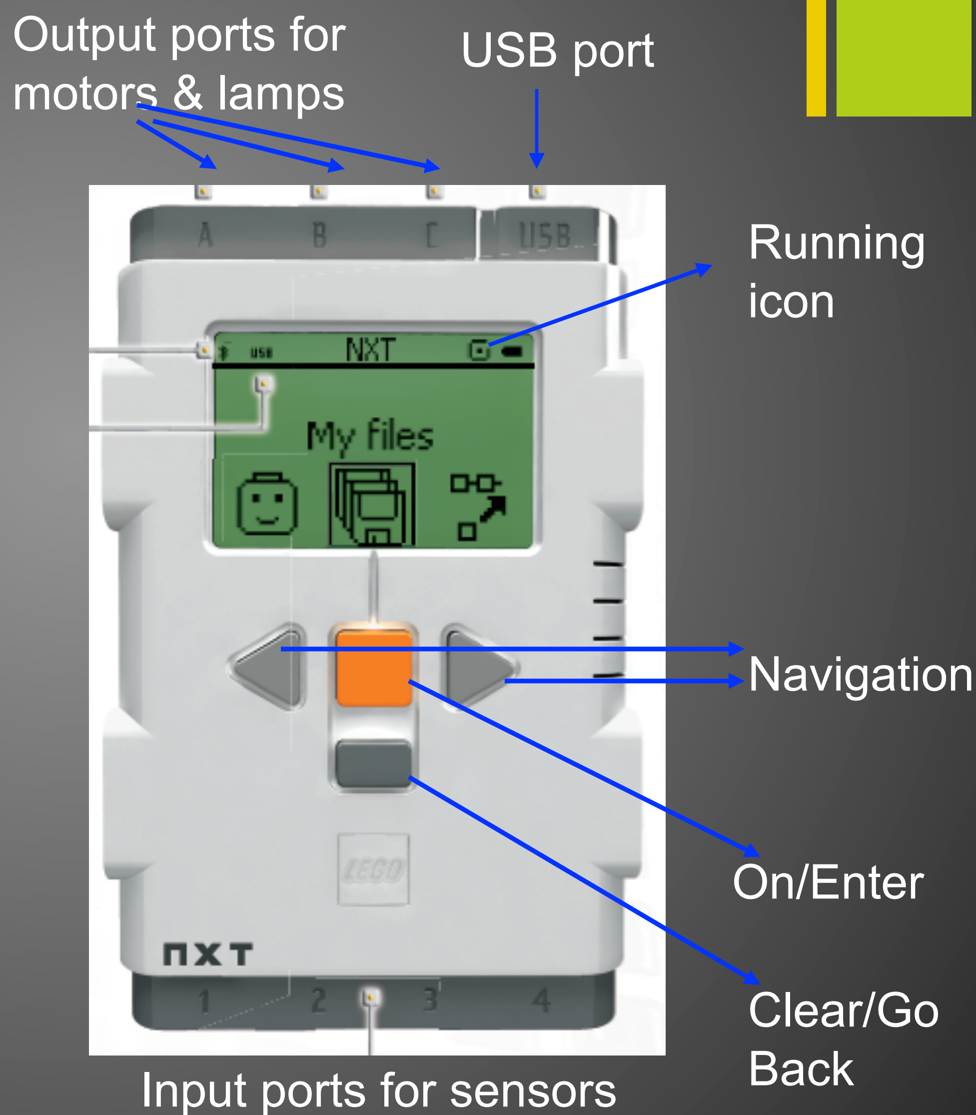
Technology Overview: Lamps and motors

Interactive Servo motors

Lamps

More on the brick

- To turn on the NXT: Press the orange button
- To turn off the NXT, press the dark gray button till you see "Turn off" on the screen. Then press the orange button again
- There are three file folders on the NXT:
  - "My files" that you download from your computer
  - "NXT files" that you program on the NXT
  - "Sound files"



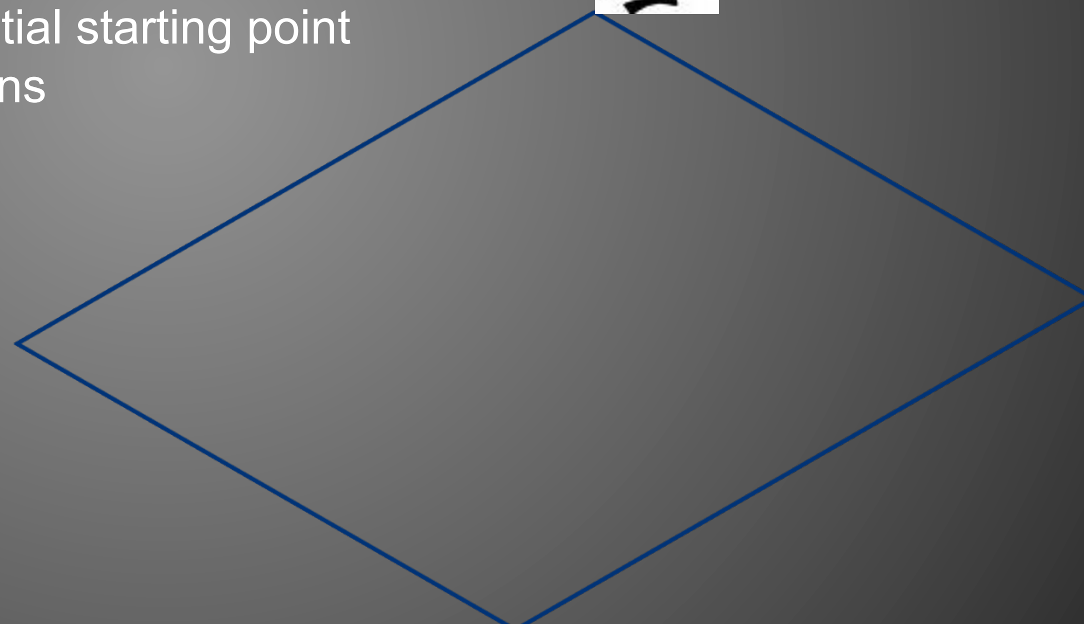
Group Exercise 1
Introduction to Programming

How do I move around the square if I can’t see and have only my team members voices to guide me?

Challenge:

Get your team member to their initial starting point
Using only the following instructions

1)Move Forward
2)Move Backward
3)Turn Left
4)Turn Right
5)Stop



+ Sense-Plan-Act

- Sense
  - Seeing
  - Touching
  - Hearing
  - Distance
- Plan
  - Use sensory information to decide on an action
- Act
  - Actuation moving the motors of the robot to complete the plan

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Planning

- Programming - The act of setting a series of steps to be carried out or goals to be accomplished

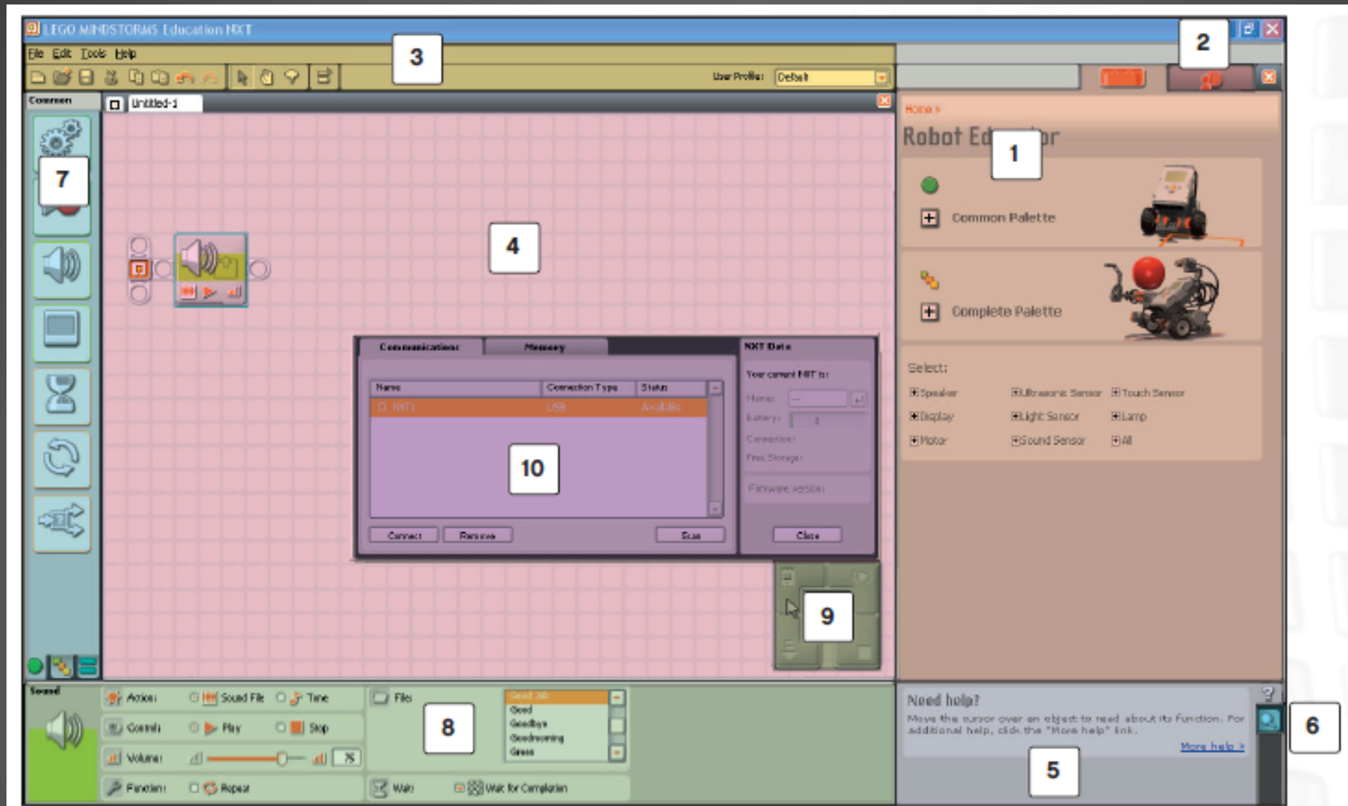
+ Programming your robot: a problem-solving process

- What do you want the robot to do?
- How must the robot behave to complete the task?
- Create the program – review and download
- Run the program
- Did the NXT behave as required (doesn't do task)?
  - Check the robot first. If there's a problem, can you fix it?
  - Next, check the program. Problem? Can you fix it?
  - Last, go back to the beginning and reread the task. Does your program really tell the robot what it's supposed to do?

Your first program

Click on the icon

+ Software User Interface



1. Robot Educator
2. My portal
3. The tool bar
4. The work area
5. Little help Window
6. Work area map
7. The programming palette
8. The configuration panel
9. The controller
10. The NXT Window

Programming Palette

Contains all of the programming blocks you need to create programs.

There are three palette categories

- The Common Palette
- The Complete Palette
- The Custom Palette

+ Common Palette

Display block
The Display block enables you to control the display on the NXT. You can type, show icons or even draw through your program.

Record/Play block
The Record/Play block enables you to program the robot with physical movement - and later play back the movement elsewhere in the program.

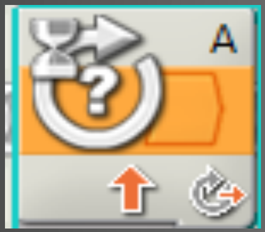
Move block
The Move block makes your robot Motors move or Lamps turn on.

Wait block
The Wait block makes your robot wait for sensor input, such as a sound or a time interval.

Sound block
The Sound block enables your robot to make sounds, including pre-recorded words.

Switch block
The Switch block enables the robot to make its own decisions, such as going left when it hears a loud sound and turning right when it hears a soft sound.

+ Get Your Move On! Programming Concepts

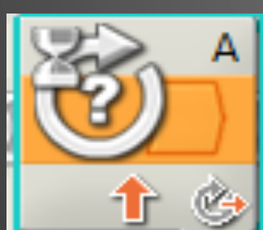


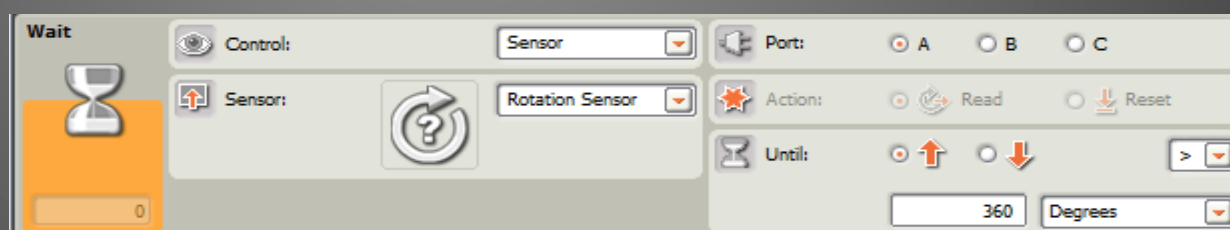
- Wait for…..
  - Sensor (rotation, touch etc.)
- Motor
  - Duration
  - Direction

Configuration Panel

Move

Wait for…





Downloading a program on your NXT

- Make sure your NXT is turned on
- Connect the NXT to your computer
- Press ‘download’ on your Controller

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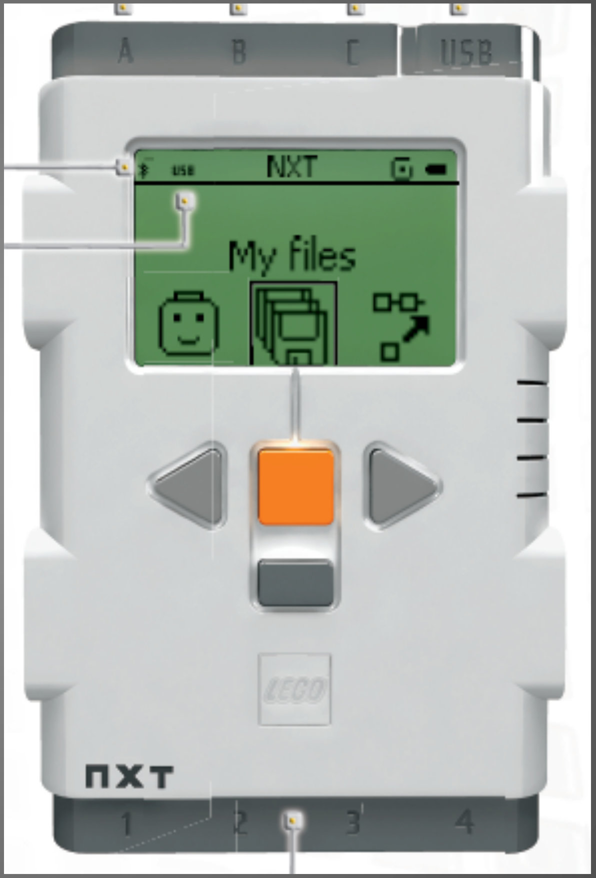
How to run your program…

- Press the orange button when the screen says "My Files"
- When you see the name of your program appear on the screen, press the orange button again



+ Programming Challenges

a) Get your move on!

1) Move Forward a Distance
2) Point Turn Left
3) Point Turn Right

b) Move in a Square

1) The hard way
2) Learn your loops

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Challenge 1: Get A Move On!

1. Create and test a program to make the robot go forward in a straight line for exactly 1 second
2. Create and test a program to make the robot go right 90 degrees
3. Create and test a program to make the robot go left 90 degrees
4. Save as three separate programs as your first name and Line (e.g., File→Save as Group#_Challenge#→Enter)
5. Create and test a program to make the robot go right 720 degrees (go round in a circle twice, clockwise)
6. Create and test a program to make the robot go left 720 degrees (go round in a circle twice, counter-clockwise)

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Get A Move On! Forward

Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Click on the blocks to learn more

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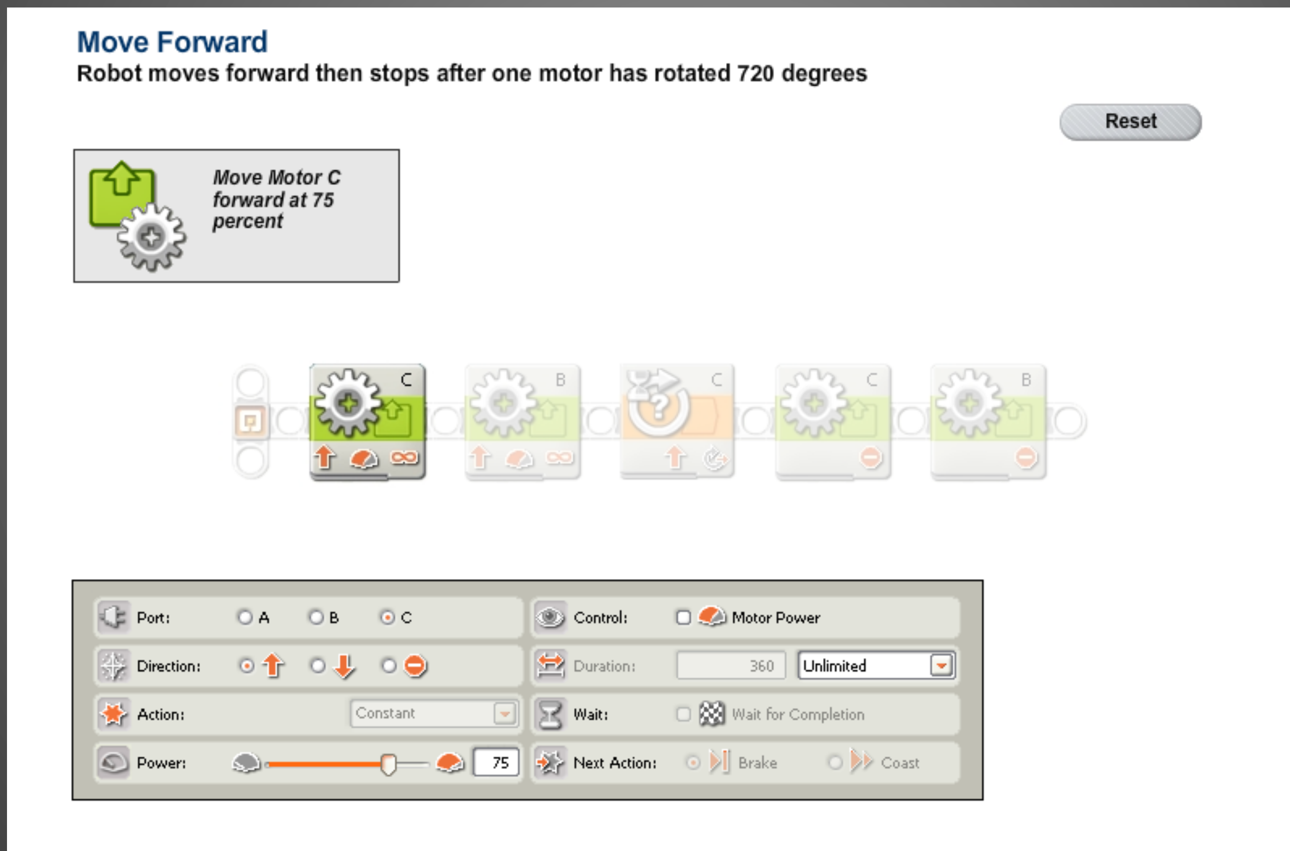
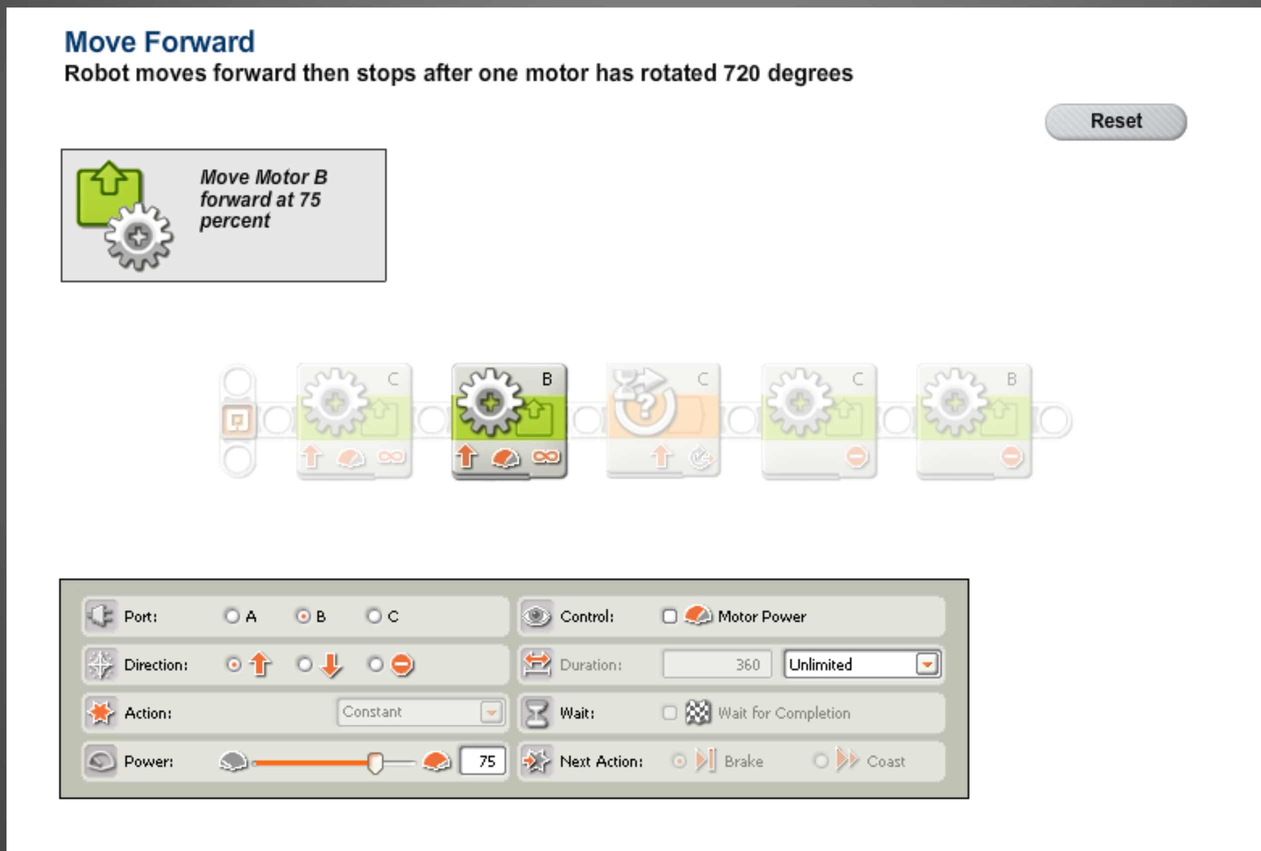
Get A Move On!



Move Forward
Robot moves forward then stops after one motor has rotated 720 degrees
Reset
Move Motor C forward at 75 percent
C
B
C
C
B
Port:
A
B
C
Direction:
Action:
Constant
Power:
75
Control:
Motor Power
Duration:
360
Unlimited
Wait:
Wait for Completion
Next Action:
Brake
Coast

+

Get A Move On!


Move Forward
Robot moves forward then stops after one motor has rotated 720 degrees
Reset
Move Motor B forward at 75 percent
Port: A B C
Control: Motor Power
Direction:
Duration: 360 Unlimited
Action: Constant
Wait: Wait for Completion
Power: 75
Next Action: Brake Coast

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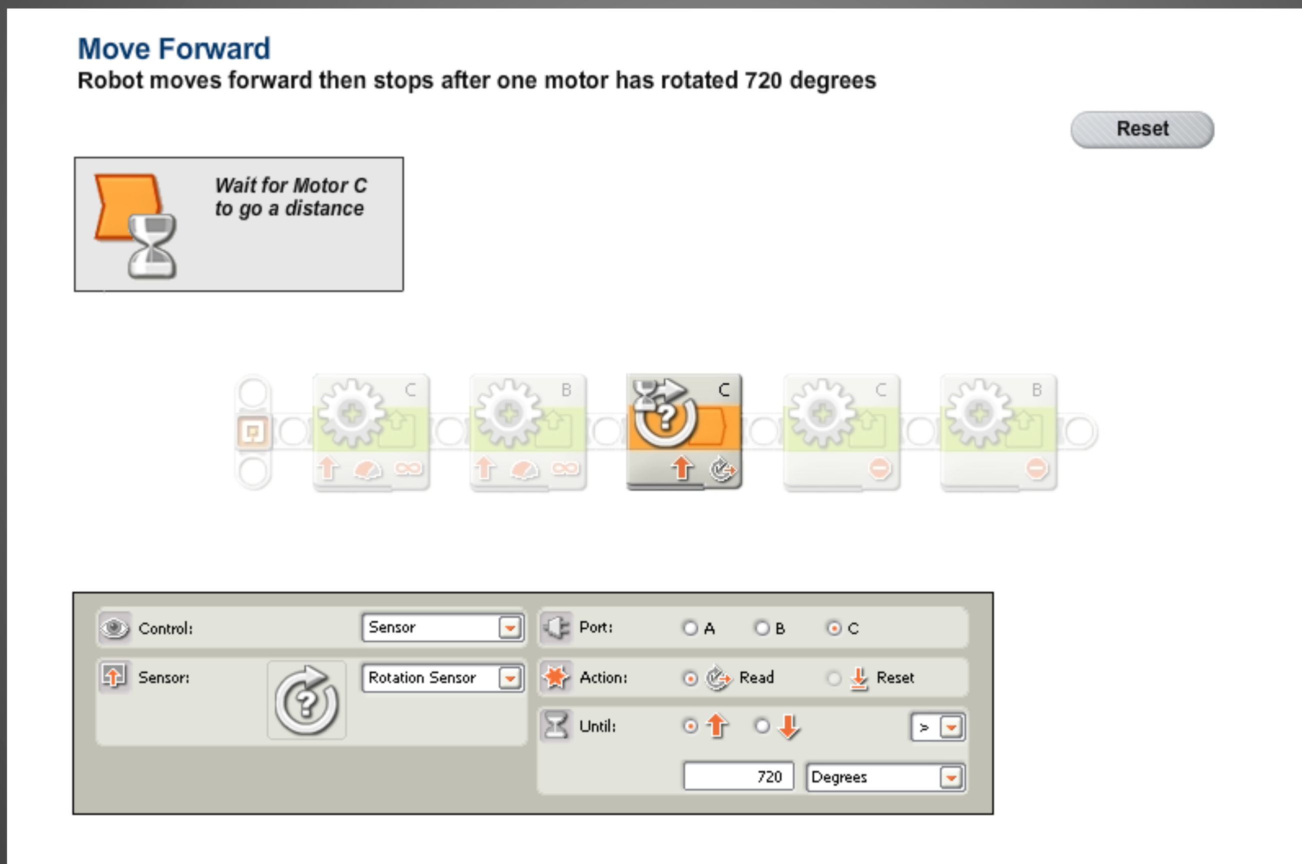
Get A Move On!


Move Forward
Robot moves forward then stops after one motor has rotated 720 degrees
Reset
Wait for Motor C
to go a distance
C
B
C
C
B
Control:
Sensor
Port:
A
B
C
Sensor:
Rotation Sensor
Action:
Read
Reset
Until:
>
720
Degrees

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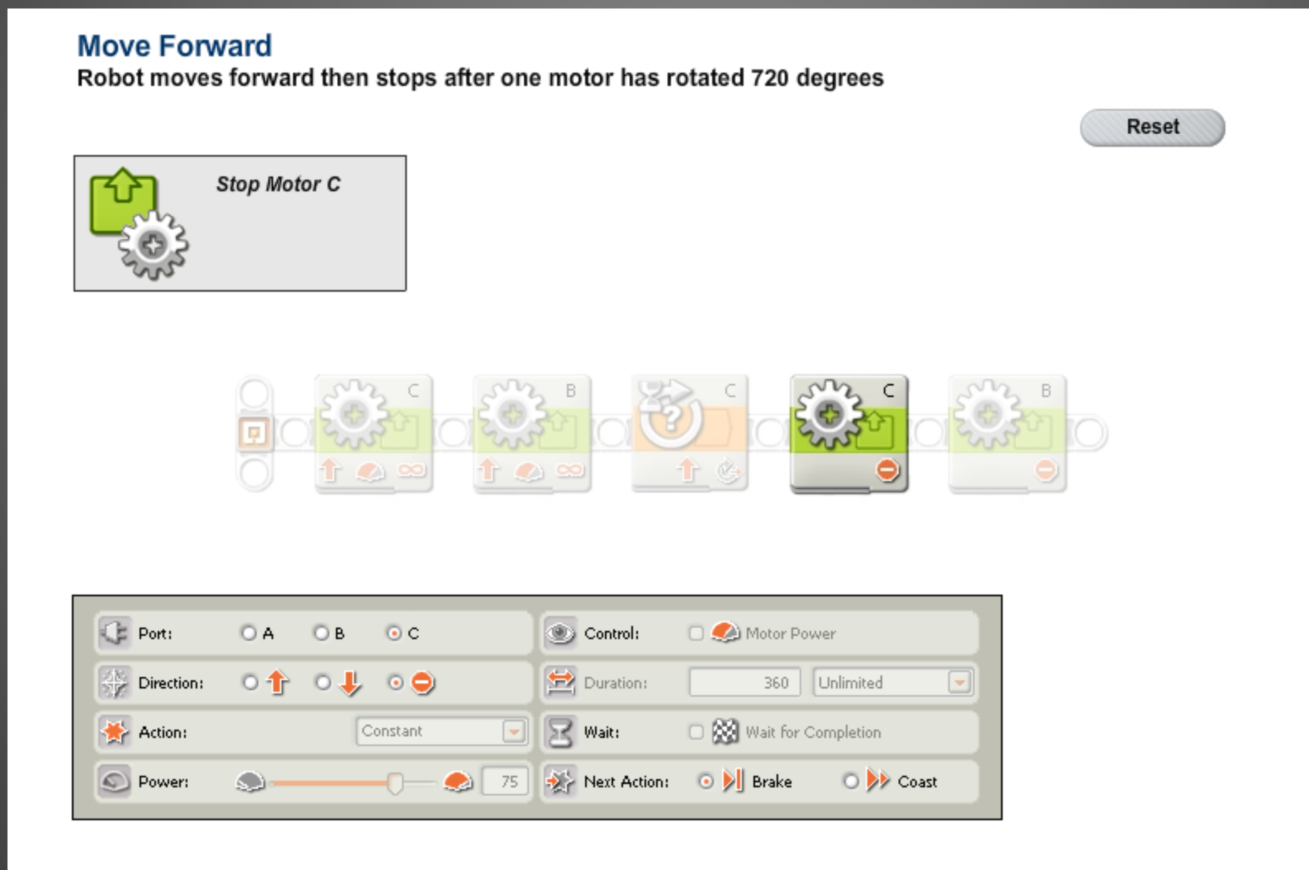
Get A Move On!


Move Forward
Robot moves forward then stops after one motor has rotated 720 degrees
Reset
Stop Motor C
Port: A B C
Direction:
Action: Constant
Power: 75
Control: Motor Power
Duration: 360 Unlimited
Wait: Wait for Completion
Next Action: Brake Coast

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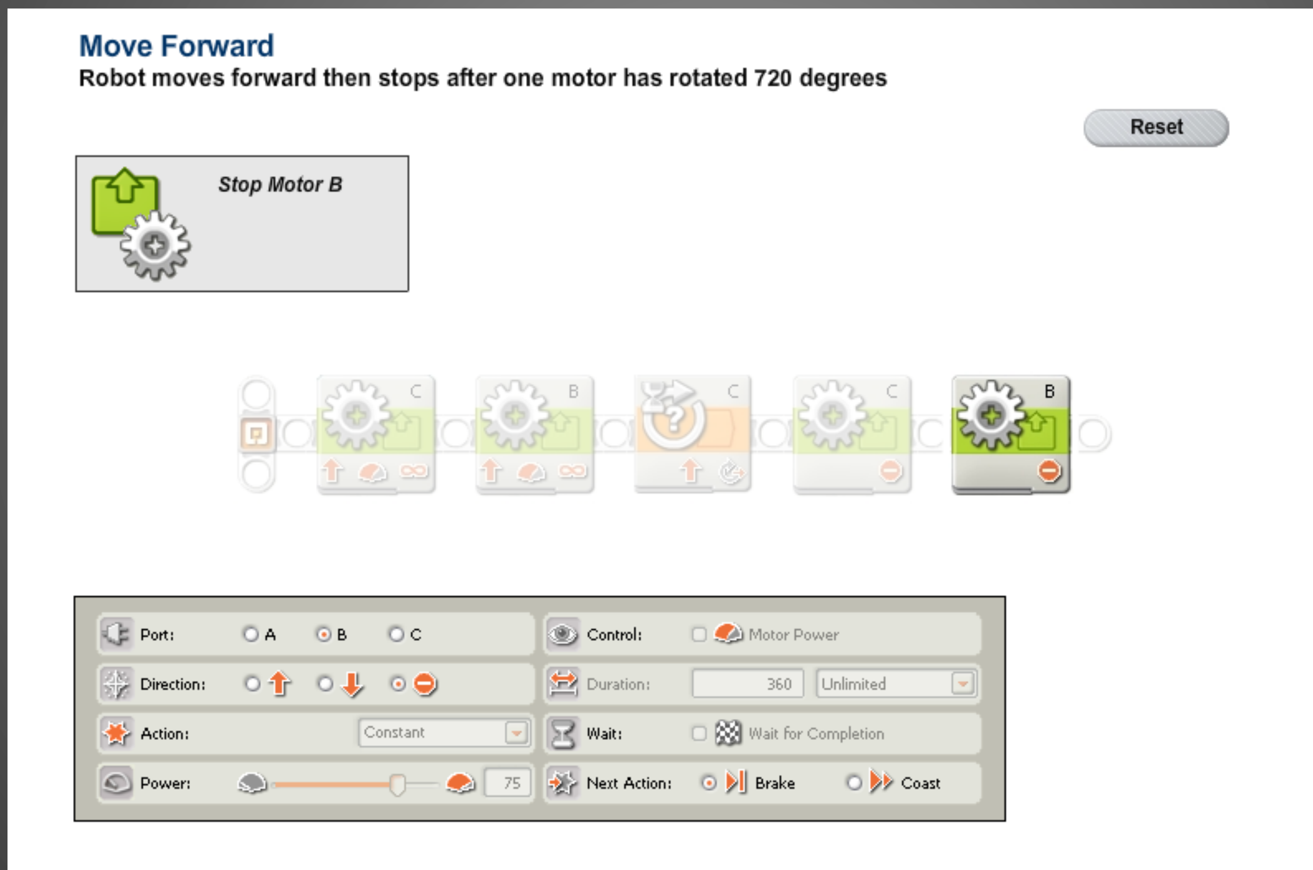
Get A Move On!


Move Forward
Robot moves forward then stops after one motor has rotated 720 degrees
Reset
Stop Motor B
C
B
C
C
B
Port:
A
B
C
Direction:
Action:
Constant
Power:
75
Control:
Motor Power
Duration:
360
Unlimited
Wait:
Wait for Completion
Next Action:
Brake
Coast

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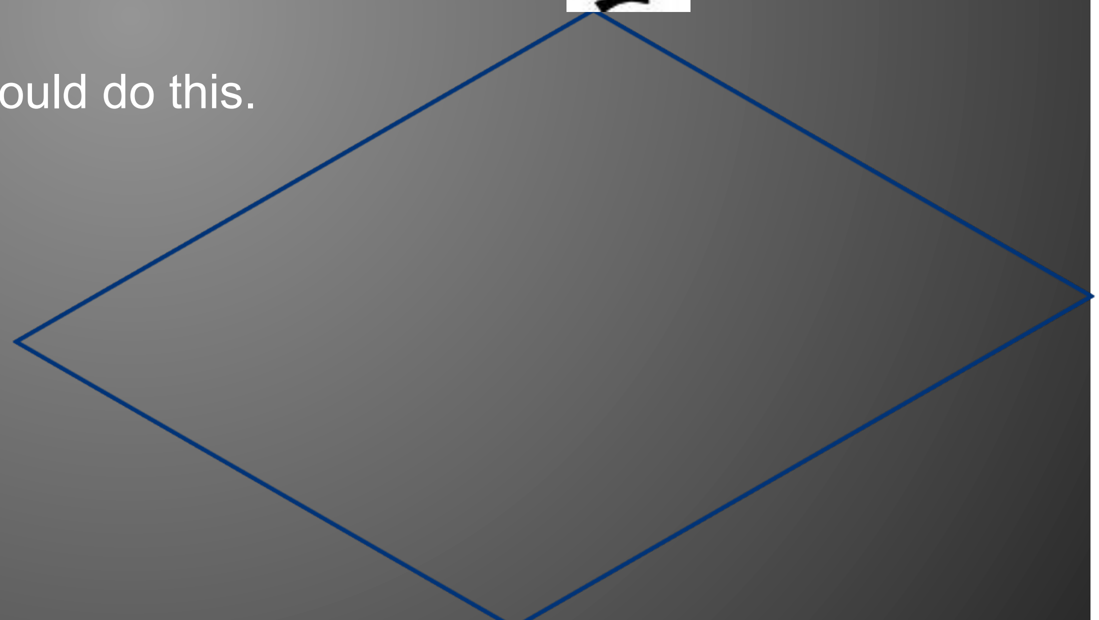
Group Exercise 2

How do I move around the square using less instructions?

Challenge:

Find a way to use less instructions to help your team mate navigate around the square

Brainstorm several ways that you could do this.



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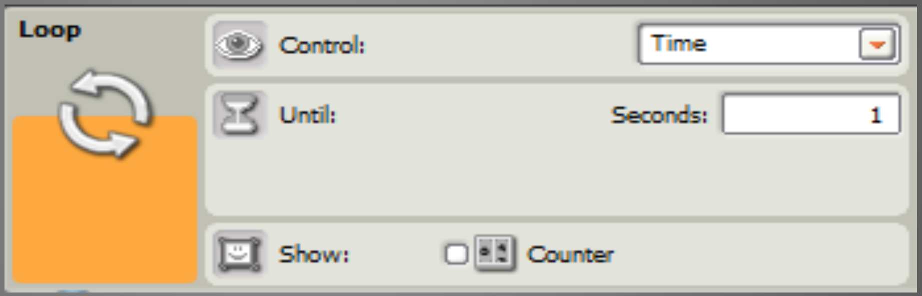
Challenge 2: Learn Your Loops

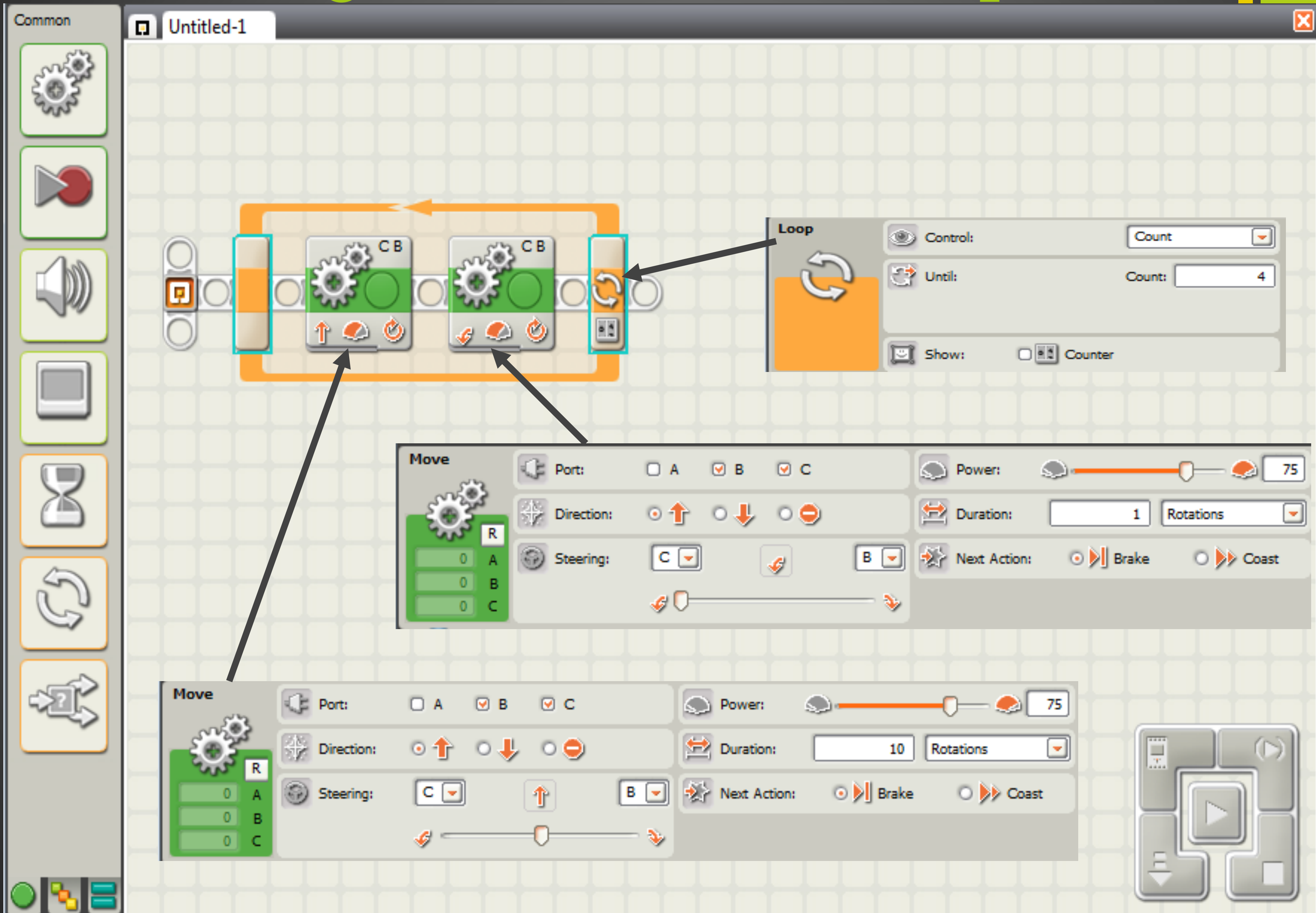
- Create and test a program to make the robot go in a square
- Save your program as your group name and Square

Configuration Panel

Loop



+ Challenge 2: Learn Your Loops



Ok, now that you know how to program a bot…..

How to start a robotics project in your county?

Starting your Own Robotics Project

Models for a program:

1. Staff driven
2. Volunteer driven, staff supported

What will you need?

- LEGO NXT robotics kit ($ 270-280)
  (Includes everything to build one robot)
- LEGO NXT software (comes with training tutorials, included in robotics kit)
- Computer - mac or pc (OS XP, 800 MHz, 256 MB of RAM or higher for pc and Mac X for a Mac)
- Internet connection (optional)
- Curriculum (optional)

+ Money, Money, Money….

- Local tech based businesses usually give small grants or are willing to sponsor a club
- Utility companies do provide educational grants
- NASA Space Grant Consortiums fund outreach programs
- Local School districts can provide grants
- Most 4-H Leader's Associations have funds for project-start up….you just need to sell the idea to them

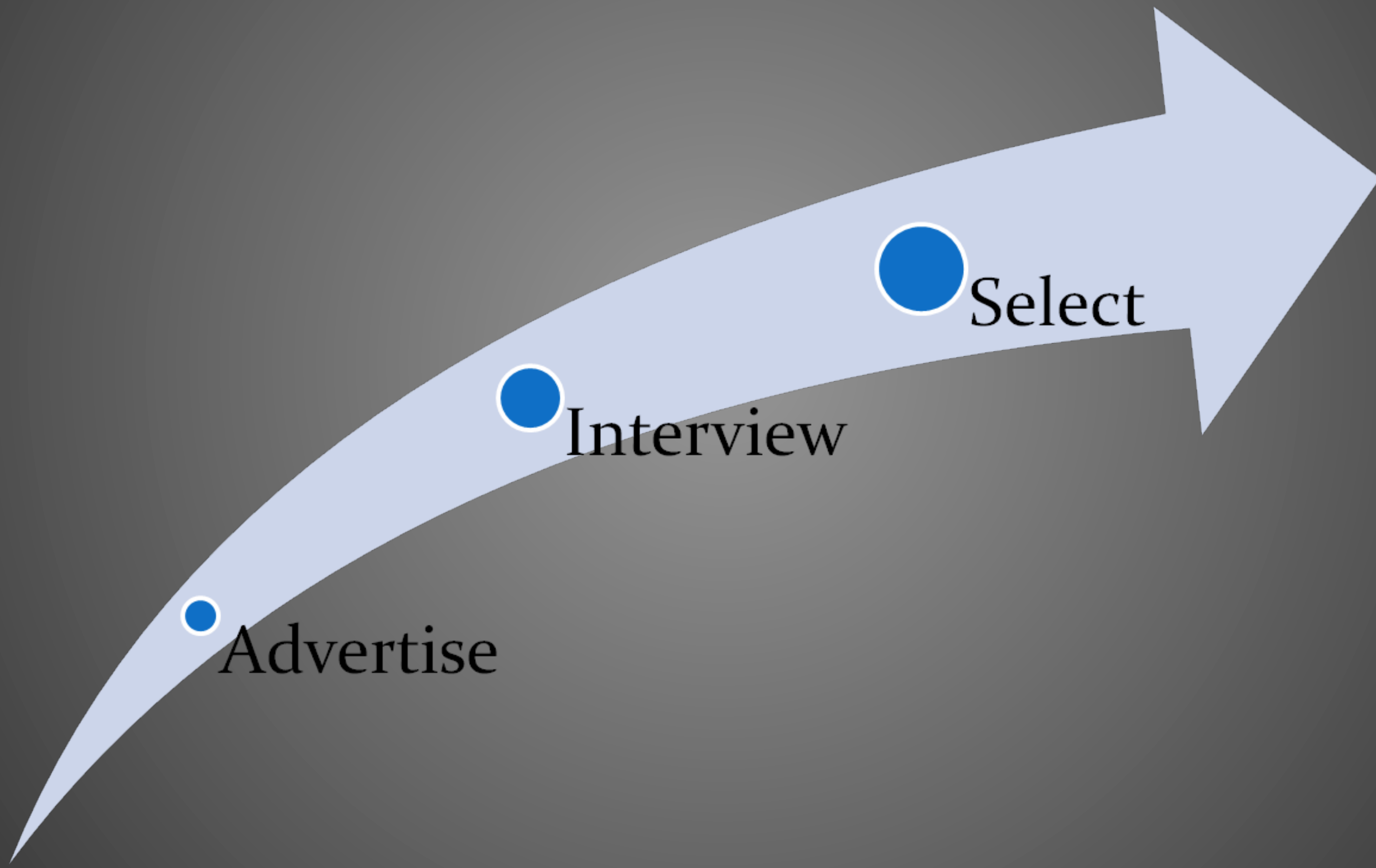
Examples of County Robotics Programs

Baltimore City 4-H Robotics Club

Objective

- To allow youth in Baltimore City to expand their knowledge, interest, and connection to engineering and science concepts and careers through a hands-on learning atmosphere

Site Selection



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Responsibilities

4-H

- Trained volunteer
- LEGO NXT Robotics Kits
- Robotics Curriculum
- Fieldtrip

School

- Computers
- Journals
- Recruitment
- Purchasing 2 replacement technology kits
- Snacks
- Transportation for 1 field trip

Club Description

- 10 youth, ages 11-13
- Youth apply to be in the program (based on interest)
- Meet once a week from Mid January-Early June
- After school program at a local middle school
- Close interaction with professional scientist
- Fieldtrip

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Club Activity Calendar

BUILDING

- January-February
- SET Abilities: Build/Construct, Communicate, Collaborate, Compare

PROGRAMMING

- February- May
- SET Abilities: Use tools, Collaborate, Predict, Hypothesize, Observe, Measure, Collect Data, Analyze, Redesign, Optimize, Model/Graph/Use Numbers

WRAP UP

- May-June
- SET Abilities: Compare, Communicate,

+

Programming

- Introduction of Programming Concept +Short Activity to Reinforce Concept
- Incremental adding of Concepts each week
  - i.e. Motor, Moving Forward, Turning, Sensors, Loop, Threshold

+ Programming

Challenges

- Longer activities that incorporate programming knowledge & skills with problem solving skills

+ Field trip

LABORATORY FOR
Computational
Sensing + Robotics
THE JOHNS HOPKINS UNIVERSITY

Their Mission: “to foster innovative robotics science and engineering research” (https://lcsr.jhu.edu/Main_Page)

Our Goal: To create opportunities for youth to connect club activities to real world research and activities

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Future Goals

- Expand to more Sites
- Connect club activities with local or national competitions
- Train current club members to facilitate robotics learning of the next cohort

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Waukesha County, Wisconsin's Robotics Program

- County-wide project
- About 40 youth members
- Robotics is a project offered within the traditional club setting
- Youth participate in the FIRST LEGO League Challenge

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FIRST LEGO® League (FLL)

- FLL is the result of a partnership between FIRST (For Inspiration and Recognition of Science and Technology) and The LEGO Group

- "FIRST LEGO League (FLL) is an exciting and fun global robotics program that ignites an enthusiasm for discovery, science, and technology in youth ages 9 to 14. Each year FLL teams embark on an adventurous Challenge based on current, real-world issues. Guided by a team coach and assisted by mentors, the youth:
  - Research and solve a real-world problem based on the Challenge theme
  - Present their research and solutions
  - Build an autonomous robot using engineering concepts"

- [http://www.usfirst.org/what/fll/default.aspx?id=390]

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FIRST LEGO® League (FLL) (contd.)

- Youth have 8 weeks from the time the challenge is announced to the tournament
- Twenty to forty local teams compete in regional tournaments
- Teams that qualify in the regional tournaments move on to compete at the State level. There are also National and International level tournaments.

+ The FLL Challenge

- Robot game
  - Design, build and program a robot prior to the tournament
- Project
  - Conduct research on project topic
  - Create a proposed solution on a problem related to the topic
  - Present the research, problem statement and solution during the tournament

+ Guidelines

- Boys or Girls
- Ages 9-14yrs old
- A student less than 9 yrs old can participate if they are socially and academically comfortable with the older group
- Maximum of 10 kids
- Minimum 1 coach (yeah right)
- Neither the youth nor the coaches need to have a science background
- Exhibit "gracious professionalism"

What do they learn/How do they grow?

- Life skills
- Problem solving skills
- Working with a team
- Designing skills
- Research & presentation

What do they learn/How do they grow?

To asses the youth's skill-level increase in robot design and building, programming and computer technology, as a result of participating in the FLL program; at the end of the season, youth were asked to compare their skill levels in each area before and after the FLL season. Given a four point scale, with choices ranging from 'poor' to 'excellent,' youth skill-level gain is summarized as follows:

	Increase by 1 level	Increase by 2 levels	Increase by 3 levels	No change
Computer skills	25%	17%	0%	58%
Programming using Mindstorms	50%	17%	25%	8.33%
Designing & building a robot	30%	20%	0%	50%
Presentation before an audience	45%	9%	0%	45%
Conduct a research project	40%	20%	0%	40%
Problem solving skills	45%	9%	0%	45%
Interest in taking SET classes	64%	0%	0%	36%
Interest in SET career	50%	0%	0%	50%

+ Sample FLL Budget

Costs				
#	**Description**	**Type**	**$ / team**	**Notes**
1	Team Registration with FIRST	Annual	200	
2	Regional Registration for tournament	Annual	50	
3	Field Setup Kit	Annual	65	
4	Robot Set (NXT)	One Time	325	
5	NXT Touch sensor	One Time	17	
6	NXT light sensor	One Time	17	
7	Table/Field	One Time	80	Approx
8	Tackle box for storage	One Time	60	Optional
9	Postage		50	Approx
10	Project Cost	Annual	Varies	Poster board, glue etc.
11	Handouts	Annual	Varies	Optional
12	T-Shirts	Annual	Varies	Optional
	TOTAL		**864**	**Min**

FLL International General Timeline

Month	Activity
May - September	Team registration on FLL website
August – Mid-September	FLL kits begin shipping
Mid-September	Challenge announced
October – November	FLL season
Mid-October	Tournament registration
November - December	Tournaments

Things to keep in mind (for any robotics program):

Expensive kits with small parts:

- Need to set a minimum age for participation (usually nine)
- Need to have stringent guidelines for usage
- Need to keep a strict inventory of all parts, checking them each time a kit is taken out and used
- Fishing tackle boxes highly recommended for keeping the small parts organized

Good Partners

- School or school district for funding, premises and perhaps teachers
- After school programs
- Local home school network

+ My involvement with FLL

- One of the 4-H parents was coaching a home schooled team
- His team gave a demonstration at the Family Fun Night
- When I was hired 2 months later, the 4-H Leaders Association (association of 4-H Volunteers) told me that I had to start FLL teams for 4-H youth
- The Leader's Association agreed to help fund starting the new teams
- Teams were sponsored by GE Healthcare & Rockwell Automation. Any team coached by employees of these two tech based corporations receive funding from them.

+ Available curriculum (for any robotics program):

- National 4-H Cooperative Curriculum System's Robotics series (RCX based) This curriculum is now outdated.

  http://www.4-hcurriculum.org/robotics.aspx

- Carnegie Mellon Robotics Academy's Robotics Engineering vols 1 & 2
  http://www.education.rec.ri.cmu.edu/

- FIRST LEGO League Challenge Curriculum (available only to FLL teams)
  http://www.usfirst.org/

Available curriculum (for any robotics program):

- University of Nebraska robotics program curriculum: GEAR-Tech-21 (GEospatial And Robotics Technologies for the 21st Century) http://4hset.unl.edu/itest/index.php
- Some LEGO Education Kits have supporting curriculum http://www.legoeducation.com/store/
- The Unofficial LEGO Mindstorms NXT Inventor's Guide, by David Purdue (can be ordered from the LEGO Education site)

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Available Web Resources

- NXTprograms.com: a free web resource for building and programming

http://www.nxtprograms.com/

- Companion website to the book The Unofficial LEGO Mindstorms NXT Inventor's guide

http://nxtguide.davidjperdue.com/

- Additional software can be found at the Robotics Academy (http://www-education.rec.ri.cmu.edu/)

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Questions? Comments?

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Thank You !

Additional Online Resources

Look here for additional resources that can be used with this curriculum!

http://www.nyx.net/~librown/robots/
http://www.nxtprograms.com/NXT2/explorer/index.html
http://www.nxtprograms.com/NXT2/segway/index.html
http://www.lego.com/education/school/default.asp?locale=2057&pagename=softu&l2id=3_2&l3id=3_2_4&l4id=3_2_4_2