JUNIOR DIVISION ROBOTICS INQUIRY

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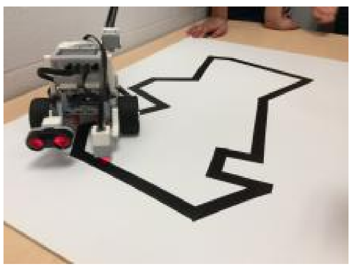
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Grade Level:

Grade 5 is the main focus for this unit, however, this unit is also highly suitable for any students in the junior division.

Strand(s) and Unit(s):

Science – Understanding Structures and Mechanisms

Math – Measurement

Math – Geometry and Spatial Sense

Math – Data Management and Probability

Language – Oral Communication

Language – Writing

Language – Media Literacy

Overview:

Junior division students will ask questions prompted by curiosity 'sparks' provided by the teacher, however, they will be encouraged to develop their own questions as the unit develops. Students will collect ideas based on, but not limited to, a series of guiding questions related to each 'spark'. Students will then critically consider the information they have gathered, narrowing the ideas they collected into essential elements that they can apply to their planning. Students will then take their detailed plan and make a robot rig or program that will help them discover the answer to their initial series of questions.

Figure 1 Guided Inquiry MakerEd Model – Students will employ this model for learning to assist them with their thinking while navigating their way through this inquiry. © 2018 Together for Learning (http://www.togetherforlearning.ca/t4l-vision-document/).

Inquiry Focus:

The main focus of this inquiry will be to help students develop skills in using modern robotic systems, such as the *LEGO EV3 Mindstorms* system, which requires the learner to grasp ideas around mechanical engineering, computer programming and computational thinking. The teacher should make every effort to nurture persistence, creative problem solving, technical precision, collaboration and effective written and verbal communication skills to help their students succeed. 'Spark' questions such as, "How do you build a stable rig?" and "How can you make the robot travel 50cm efficiently?", will get the students thinking creatively as they try to find answers to these open-ended tasks about the world of robotics.

Timeline:

This unit should take between 22 to 30 hours of in-school time with students working collaboratively in groups of three or four to complete work with the robotic equipment, however, this could be extended as the level of interest by students was high. Chunking time into one or two-hour sessions gives students good minds-on time and a chance for the teacher to conduct real-time, ongoing assessment. Hands-on learning time works best when a resource teacher can assist, so one professional can facilitate instruction and one professional can focus on assessment while the inquiry takes place. If a resource teacher is not available, a lone classroom teacher should expect to add 6 to 12 hours to conduct real-time assessments as the unit is underway. This timing is based on eight separate, past experiences working with individual straight and split grade 5 classes. All classes featured students with a wide variety of learning styles, and most students were ELL.

Time spent on this outside of specific hands-on time with the robotic equipment varies and is open-ended depending on where the student inquiry takes you. Taking time to help students understand key terms regarding structures and mechanisms [system, tension, torque, load, pulley, gear, force, speed], measurement, and geometry/spatial sense has been beneficial to all classes in the past [refer to current, related ministry curriculum documents for additional guidance]. Classroom teachers have delivered introductory lessons and some smaller, practical application tasks to get students comfortable with the ideas in the week prior to beginning the hands-on robotic portion during the previous eight collaborations.

It is also recommended that an understanding of computer sciences is beneficial for students. All students that have previously worked through this inquiry have at minimum worked to understand the fundamental concepts and thinking behind computer sciences [*Sequencing, algorithms, loops, events, variables, persistence*] and many went on to using *Scratch 2.0* to create programs related to literacy and/or numeracy. This work in computer sciences took place several weeks prior to beginning their robot inquiry [varied in length in each instance from a few days of teacher curated modules on fundamentals, to a 3-week unit connecting coding with narrative writing], and was delivered as a transferable skill used to express their ideas [*CODE to learn,* not *learn to CODE*].

Big Ideas:

This collaborative inquiry is based on the big idea of ***"How do we become robot makers?"*** This question has proved to be an excellent catalyst for exploration and discovery, and has given students an effective way of focusing their thinking. Using this big idea has made strong connections between science, numeracy and literacy learning, and has activated prior knowledge from student's work with pulleys, gears and other simple machines. This collaborative inquiry is about an interdisciplinary approach to learning based around the *Guided Inquiry Model* (http://bit.ly/guidedinquiry-big) and *Maker Education Model* (http://bit.ly/makered-guidedinquiry).

The main grade 5 big ideas for the Ontario Science and Technology curriculum is structures and mechanisms throughout our environment have forces that act on and within them. However, delivering this unit to split classes has found excellent links to the big ideas of investigating how pulleys and gears change the speed, direction, and motion of, and force exerted on, moving objects [Gr4], how pulleys and gears make it possible for a small input force to generate a large output force [Gr4] and how technological and scientific advances that enable humans to study space affect our lives [Gr6].

Overall Expectations:

SciTech

[**1**] identify forces that act on and within structures and mechanisms, and describe the effects of these forces on structures and mechanisms [Gr 5].

[**2**] investigate ways in which pulleys and gears modify the speed and direction of, and the force exerted on, moving objects [Gr 4].

[**3**] demonstrate an understanding of the basic principles and functions of pulley systems and gear systems [Gr 4].

Math

[**1**] estimate, measure, and record perimeter, area, temperature change, and elapsed time, using a variety of strategies [Gr 5].

[**2**] determine the relationships among units and measurable attribute [Gr 5].

[**3**] identify and describe the location of an object, using the cardinal directions, and translate two-dimensional shapes [Gr 5].

[**4**] collect and organize discrete or continuous primary data and secondary data and display the data using charts and graphs [Gr 5].

[**5**] read, describe, and interpret primary data and secondary data presented in charts and graphs [Gr 5].

Specific Expectations:

SciTech

Gr 4 - Understanding Structures and Mechanisms – 2.1, 2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.4, 3.5

Gr 5 - Understanding Structures and Mechanisms – 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 3.3, 3.4

Gr 6 – Understanding Earth and Space Systems – 1.1, 2.3, 3.4

Math

Gr 5 – Measurement - estimate and determine elapsed time, estimate and measure the perimeter and area of regular and irregular polygons, estimate and represent time intervals to the nearest second, select and justify the most appropriate standard unit (i.e., millimetre, centimetre, decimetre, metre, kilometre) to measure the perimeter of various polygons.

Gr 5 – Geometry and Spatial Sense – identify and classify angles, measure and construct angles using a protractor, identify and classify triangles based on angle and side properties, locate an object using cardinal directions and a coordinate system.

Gr 5 – Data Management and Probability – collect data by conducting an experiment and record observations and measurements, collect and organize primary data using appropriate tables and labels, interpret and draw conclusions from primary data presented in tables and charts, compare similarities and differences between two related sets of data

Key Concepts:

The key concepts of this inquiry-based unit are all centered around computer science and robots. Students will understand the role of robots in today's world, design and build stable rigs and mechanisms, and problem solve when programming robots to accomplish tasks. While they undergo this endeavour, students will actively apply numeracy and literacy skills as they are immersed in many junior division concepts integral to understanding structures and mechanisms.

Prior Skill Sets:

Students should have experience building structures and mechanisms that remain rigid, regardless of the forces acting on them. These structures should be able to withstand different loads, allow for versatility when modifying systems, and have a decent tensile strength. Building with *LEGO Technics* components would be ideal, but any systems involving struts, axle/rods, pegs, and a variety of gears/pulleys would work well.

A working knowledge of computer science fundamentals, such as sequencing, events, loops debugging and conditionals, will be advantageous to students [Beginner, ELL friendly computer science fundamentals courses are available at https://studio.code.org/s/coursea-2018 (https://studio.code.org/s/coursea-2018). This is not essential however, as the *LEGO Mindstorms* uses the highly intuitive 'blocky' coding interface, and students will gain an understanding quickly. This unit will walk students through the use of the *LEGO Mindstorms* system, so prior work with this system is not necessary.

Teachers should take time to understand more about computer science and the LEGO Mindstorms EV3 system. Reading the resource from *Canada Learning Code* [http://bit.ly/CLC-TeacherGuide (http://bit.ly/CLC-TeacherGuide)], getting hands on with the EV3 kit, and using tutorials from *LEGO Education* [http://bit.ly/ev3-intro (http://bit.ly/ev3-intro)] will assist in this process.

Prior Knowledge:

These grade 5 students will use their knowledge of movement [Gr 2], strong and stable structures [Gr 3], forces [Gr 3] and pulleys and gears [Gr 4] to build functional robot rigs. The student's robots will be put through speed and terrain testing during this unit, and if students are able to employ prior knowledge and apply newly acquired ideas regarding designs put under stress [Gr 5, specific expectation 2.4] and force required to accomplish different tasks [Gr 5, specific expectation 2.2], they will be successful. Review and pre-teaching this material will be beneficial when the students apply their learning.

Students should have an understanding at the basic level of the three math 'specific expectations' listed above, an understanding how to write reports, and how to storyboard a media presentation. Students will be able to apply these numeracy and literacy skills in real-time when problem solving during the collaborative inquiry.

Materials and Equipment:

For the prior skills/knowledge building portion of this unit, *LEGO Technics* (https://shop.lego.com/en-CA/Compact-Tracked-Loader-42032) or *LEGO Mechanisms* (https://education.lego.com/en-us/products/simple-powered-machines-set/9686) sets are recommended to help students gain confidence and ability to build structures and mechanisms with this material. In terms of building computer science competencies, teachers and students with computer/internet access can use *CODEorg* [www.code.org (file:///C:/Users/Kristofor/Desktop/www.code.org)] resources for fundamentals skills development [algorithms, events, loops, variables, conditional statements, debugging], and *Code Club Canada* [www.codeclub.ca (file:///C:/Users/Kristofor/Desktop/www.codeclub.ca)] to work through *Blocky* code projects in *Scratch* at a more advanced level. The remainder of science, numeracy and literacy skills employed with this unit build on what is already being done in most Canadian classrooms, and no special resources are required.

For the main inquiry unit, each collaborative inquiry group of students will require the following;

- One [1] MS based laptop

- One [1] LEGO Mindstorms EV3 set*

*NOTE: The LEGO Mindstorms NXT set can also be used, but will offer some computational thinking limitations due to the more primitive sensor set.

- One [1] metre stick

- One [1] 30cm ruler

- One [1] tablet with camera

- Method to log inquiry ideas [log book, Google Docs/Sheets, MS Word/Excel]

- *LEGO Mindstorms* software [http://bit.ly/ev3-software (http://bit.ly/ev3-software)]

- *Digital Whiteboard* App [i.e. *Educareations, ShowMe, Explain Everything*] or *Video Presentation* App [i.e *Adobe Spark, Videolicious*]

- Stationary supplies

A Wireless internet enabled laptop and/or tablet to support triangulated assessment practices and an LCD projector to display digital content are required. *Apple TV, Chromecast,* or *Epson BrightLink* are required to bridge the computer/tablet with the projector. Teachers will create a series of challenge mats using 75cm x 50cm foam board and electrical tape [black, green, red] based on the goals of lessons 3 and onward. MDF and balsa wood strips can also be employed, especially for the unit extensions, so the durability of the challenge mats does not become an issue.

Safety:

Students need to respect all robotic equipment and other student's creations to prevent delays and disappointments. Sensors and control brick electronic components are fragile. *LEGO Technics* components are small in size, and complete sets are integral to success.

Teachers will be responsible for creating challenge mats and robot testing environments. One unit extension will involve a substantial challenge board, and will require several tools to complete. Observe standard safety procedures for an 'Industrial Arts' class (https://www.edu.gov.mb.ca/k12/docs/support/ia_safe/safe.pdf) [i.e. Wear safety goggles when operating a saw or hammer] when constructing challenge mats and robot testing environments.

Instructional Planning and Delivery:

All segments of this collaborative inquiry unit are based around the guided inquiry/MakerEd model outlined at the beginning of this document. After students are given explicit instruction around an inquiry spark, the students' progress through the four stages of inquiry is continuous until reaching the desired result. Teacher[s] are consulted at each stage to ensure student groups are prepared to move on, since the model can be separated into two categories.

[1] The 'asking questions' and 'collecting ideas' portion of the inquiry often deals with a large amount of collaboration, discussion, examining artifacts, recording details, and information management using print and digital resources within the group. These two steps in the inquiry process are best accomplished in the library learning commons. Teachers can ensure students get most of the required information through guiding questions prior to moving on to help with time management.

[2] The 'processing/planning' and 'making' portion of the inquiry again have groups of students collaborating and discussing, but this portion involves a hands-on approach in a lab or makerspace. Students create diagrams, apply ideas in real-time, make modifications along the way, and create something to share their discoveries and reach their goal.

If students get adequate feedback and consultation time with teachers during the first 2 stages of the inquiry process, they will often only have to revisit 'asking questions' and 'collecting ideas' quickly when adjusting their plans and creations. This will help the inquiry move along at an efficient pace and limit frustrations, and help nurture intrinsic motivation and innovation.

Lesson 1	*Overview* Using the inquiry spark of "**Why are modern robots amazing?**", students are given an overview of the current state of robotics and robot design. Discussions and presentations focus on innovative robot concepts, organizations leading the industry, ethics, and the principles that help make robots effective. The outcome will hopefully spur interest and intrinsic motivation to discover more about robotics, and add to the BIG idea of "How do we become great robot makers?".

Timeline	*Teaching Sequence*
2 to 4 hours	[1] Have students begin asking questions regarding some key ideas one can observe about modern robotics. These include; - The need for **precise programming** as it relates to numeracy [accurate measurements and data, logic sequencing] and literacy [explained clearly with good facts and details]. - The importance of robot's **understanding problems** they encounter [breaking down large problems into small chunks and understanding the limits to what the robot can understand about the environment it is in or what actions it would be able to do]. - The connection that modern robots have between **sensors, programming and actions**. This idea brings the first 2 points together, as one must understand that robots need information from their environment [i.e. a light sensor is monitoring ambient light in the environment], which the robot then analyzes using its programming [i.e. a conditional statement saying *if* the light intensity drops to 10% or less, *then* provide power to port A] and an action takes place in the real-world [i.e. Port A is connected to a headlight, which then turns on]. - The concept of **computational thinking**. Problems to overcome are everywhere and there are several ways to solve them. The goal of robots [or humans] should always be to find the best, most straightforward solution possible to these open-ended problems, while considering the current state of other factors in the environment. - The idea of **ethics**. Robots should be helpful and safe for humans. All factors associated with a project should be taken to account when designing and operating a robot to try and limit the robot's negative impact. [2] Students will collect ideas to help answer their questions and to elaborate on the principles using print and digital resources. Teachers should make an effort to curate resources that reflect the current state of robots from the consumer or academic sectors when they deliver this portion of the inquiry. At the time of writing this document, examples of state-of-the-art robots could include; *Honda Asimo, Google Waymo,* or *Nasa Valkyrie*. Adding a DIY robot example, such as the *IBM / Star Wars RaspberryPi Droids*, also help in making accessible connections to the ideas and industry for students. [3] Students should plan out a code-of-conduct for their team, based around key concepts outlined at the beginning of lesson 1. Each group should process the ideas the collected to isolate the key concepts, and eliminate opinions or bias. [4] The student groups make their code-of-conduct, which will help guide them through the inquiry.

Guiding Questions

Why is precise programming important when coding your robot?

How do sensors help a robot work better?

How do sensors help the robot think?

How are robots engineered?

Why is precision a factor when designing and building a mechanical system?

What materials are robots made of?

Why do most robots need to be so rugged and tough?

How should a robot's artificial intelligence try to solve a problem it is presented with?

How can robots keep people and the environment safe?

Lesson 2 *Overview*

Using the inquiry spark of **"How do we build a sturdy, stable robot rig?",** students will work to design and build their own *LEGO Technics* robot platform which incorporates the *LEGO Mindstorms EV3* control brick and a combination of motors with a wheel attached to each.

Timeline	*Teaching Sequence*
3 to 4 hours	[1] Have students begin asking questions about what makes an effective design based on the components and abilities of the *LEGO Mindstorms* kit. Students will have to ensure the rig is stable, strong, sturdy, and include mounts for mechanisms and sensors. [2] Student groups should collect ideas based on examples of similar structures and mechanisms [cranes, cars, NASA & CSA Mars rovers, construction scaffolding], strong 3D geometric shapes, symmetry and industrial design, and engineering examples from *LEGO Education* [http://bit.ly/ev3-intro (http://bit.ly/ev3-intro)]. Groups should also have a chance to examine and test *LEGO Technics* components* from their kits to better understand their strengths and limitations. *NOTE: Students should be informed that *LEGO Technics* components are intentionally colour coded. Darker coloured components offer strong, more rigid connections, while lighter coloured components offer looser connections to allow pieces to rotate, swing, or move within a mechanism. [3] Students should then evaluate the design ideas they collected and form a robot design plan that is strong and sturdy, but is also as small and compact as possible. The robot rig is ideal if the XYZ is 25cm x 25cm x 25cm or less, and only include practical components such as mount arms, expandable drive trains, pivot wheels or pivot balls [spoilers, mini-figures, spikes, and stickers are examples of unnecessary design elements]. Student's designs should use precise measurements and descriptions, so if the plan needs to be revisited later during the inquiry, it can be quickly understood and acted upon. If students have difficulty with their design, suggest a basic, one motor rig from *LEGO Education* [http://bit.ly/ev3-basic1 (http://bit.ly/ev3-basic1)] or using the two motor rig detailed in the EV3 kit's print instructions [http://bit.ly/ev3-basic2 (http://bit.ly/ev3-basic2)] as a starting point that they can modify and make their own. [4] Student groups will collaborate on making their robot rig.

Guiding Questions

What is a truss? Can you give an example?

How can you find the line of symmetry on a vehicle?

How do the Mars rovers use sensors? What are they mounted on?

What is a wheel and axle?

How can we use gears?

How can we use a fixed pulley?

What are strong, 3D shapes?

How can we attach the large motors and control brick securely, but still have access to the ports and buttons?

Lesson 3 *Overview*

Using the inquiry spark **"How can our robot travel 50 cm?",** students will test their rig and learn basic '**dead reckoning' [DR] programming**. *DR programming involves programming motors and movement based on exterior variables and fixed points, rather than relying on the input of sensors.* This is a basic form of programming that will help students detect design flaws in their robot's structure early on in the inquiry.

Teachers should use a 75cm x 50cm piece of foam board to create a challenge mat with 50cm straight line marked with black electrical tape. Having one or two of the challenge mats ready will allow students access to a consistent testing ground and a monitored location for robots to operate in.


(https://connex.stao.ca/sites/default/files/media/sch-ev3-l3a.jpg)

Timeline	*Teaching Sequence*
2 to 4 hours	[1] Students begin asking questions about how to talk to the robot through programming and what the robots response will be.

[2] Groups will begin collecting ideas about what they can physically calculate in the real-world, such as the distance the robot travels when the wheel rotates once, and how these real-world details be reflected in a digital language that the robot can understand. Examining the role of DR robots in the real-world [factories, simple toys, basic appliances] will help students understand the simplicity and dangers of these types of robots. Students should understand the interaction between hardware [the robot] and software [the computer programming language] by using this e-resource from *CODEorg* [http://bit.ly/ev3-hardwarecode (http://bit.ly/ev3-hardwarecode)]. Students should also collect ideas regarding the specific computer sciences interface used by *LEGO Mindstorms* by examining this e-resource from *LEGO Education* [http://bit.ly/ev3-learn-software (http://bit.ly/ev3-learn-software)].

[3] Groups should create a plan by illustrating the sequence of steps the robot needs to follow to get the job done. Students should include measurement details and predictions, as well as a T-chart to record results.

[4] Students make a computer program using exclusively the ‘green category’ of coding blocks, upload the program to their robot, and test the robot on the challenge mat. Prompt groups to return to the planning stage if they do not travel the distance completely, efficiently [i.e. takes the least amount of time possible to travel the distance safely], or with precision [i.e. robot doesn’t meander while travelling and stops exactly on the 50 cm mark]. Once a group has success in travelling exactly 50cm, ask them to adjust the torque levels of the motors and observe how it effects the robot’s performance.

*EV3 DR basic code example for teacher use - http://bit.ly/ev3-DR-50cm-code (http://bit.ly/ev3-DR-50cm-code)

Guiding Questions

What is a ‘Dead Reckoning’ or DR robot? Where do you find these kinds of robots?

What will the robot’s motors have to do to drive forward?

When the robot’s wheel rotates <u>once</u>, how many centimetres does the robot travel?

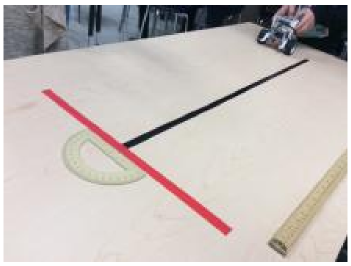
How fast should the robot travel to make its movements precise and efficient?

Should your robot move based on amount of time passed or the number of wheel rotations?

Does the amount of torque [power levels] effect the distance the robot travels?

Lesson 4	Overview

Using the inquiry spark **"How can we make our robot the fastest**?", students will work to get their robot to travel 100cm, turn 180° and return to the start position in the shortest time possible. Using black electrical tape to create a 100cm straight line in the centre of a rectangular table works well as the challenge mat for this lesson. The teacher will also require a stop-watch and should display robot times to encourage student groups to persevere, and improve their designs and programs.



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Timeline *Teaching Sequence*

5 to 6 hours

[1] Student groups should start asking questions regarding ways their robot can get faster. Students should focus on finding out how to build more complex DR algorithms using the 'green code' blocks, but students should also wonder how altering their robot rig structure and/or mechanisms could optimize performance.

[2] Students collect ideas regarding gear systems, gear ratios, fixed pulley systems, different types of drivetrains. Students should also examine what make vehicles fast, such as lightweight materials and sleek design.

[3] Students should process their ideas by pinpointing realistic modifications that will boost performance when planning things out. Since the robot will be put through time trials, groups should record results of each design or programming modifications as well, using either charts or graphs. Teachers should stress the need to work hard at analyzing results and to patiently make small changes, rather than rushing onto the next alteration if something doesn't work out. If students are stuck on what changes might be effective, prompt them to explore gear ratios, as this is usually the quickest way to see noticeable changes in the robot's speed.

[4] Students should focus first on making a computer program that accomplishes the task of moving 100cm forward, turning 180° and driving 100cm back to the start position. Groups should then start altering their robot rig's structure and/or mechanisms.

*EV3 DR three-part algorithm code example for teacher use - http://bit.ly/ev3-DR-3part-code (http://bit.ly/ev3-DR-3part-code)

Guiding Questions

- What is a protractor? How do you use it?

- How do you make your robot turn 90 degrees? ...180 degrees?

- What will the robot's motors have to do to turn?

- When the robot's wheel rotates <u>once</u>, how many centimetres does the robot travel?

- How much power should your motors use to make your robot's movements efficient and precise [*defined in lesson 3*]?

- How should the robot motors operate to get the best results?

- How can gears make your robot speed up? What are gear ratios?

- How can a fixed pulley system power multiple wheels? Does tension matter?

- Why does your CODE algorithm need to be in an exact sequence?

Lesson 5 *Overview*

Using the inquiry spark **"How can we get our robot to travel the perimeter of an object**?", students are asked to apply exact, real-world measurements to optimized algorithms that should now contain 'loops'. The 'orange code blocks' will help students create 'loops'. Teachers should build challenge mats on 75cm x 50cm foam board and black electrical tape that feature 2D equilateral shapes. These could include a square, triangle and pentagon. Some flexibility is built into this lesson to account for unit time management, meaning you can add many shapes if students are working ahead, or have fewer shapes if time is limited.

(https://connex.stao.ca/sites/default/files/media/sch-ev3-l5a.jpg)

Timeline	*Teaching Sequence*
4 to 5 hours	[1] Students should ask questions about what number facts they will have to gather to calculate perimeter of the various 2D shapes, and the degrees of rotation the robot will have to turn at each corner. Groups should also be wondering how to optimize a DR program so the algorithm isn't unnecessarily long [too many steps will lead to difficulties in debugging]. [2] Students should collect ideas about the length of the side of each shape using appropriate units of measurement, and calculate angles of rotation using protractors. Students should also work to understand loops within the EV3 programming software by using this e-resource from *LEGO Education* [http://bit.ly/ev3-loop (http://bit.ly/ev3-loop)]. [3] When planning out their optimized computer algorithms, students should take these findings and compare them to ideas and plans from previous lessons in order to make logical predictions about their DR programming. Once they have discussed possible connections, they should draw out possible algorithms with loops in mind, making connections between the number of sides and how many times a group of CODE will repeat. [4] Students will make programs so that their robot precisely travels the perimeter of the assigned challenge mat shapes. By this stage, you should see some groups accurately program their robot immediately to get around some shapes using their prior knowledge and experience, and be sure to get these students to share their thinking with the class. *EV3 DR perimeter code example for teacher use - http://bit.ly/ev3-DR-cube-code (http://bit.ly/ev3-DR-cube-code)

Guiding Questions

- What would be an appropriate unit of measurement to calculate the perimeter of these shapes? [eg. Metres, Centimetres, Kilometres, Millimetres, Decimetres, etc.]

- What is the perimeter of the shape on each challenge mat?

- How can we use a protractor to help accomplish this task?

- What type of angle will each of the turns be?

- How can the number facts from the previous challenges help us complete this challenge?

- What will our optimal CODE look like?

- When we think about CODE, what is a LOOP?

- If the robot's wheel rotates 360° how far does it travel? ...180°? ...90°?

- How much power should your motors use to make your robot's movements precise and efficient [*defined in lesson 3*]?

- How should the robot motors operate to get the best results?

Lesson 6

Overview

Using the inquiry spark **"How can we make our robot see?",** students will begin to explore sensors, with a focus on the EV3 colour sensor. The student's robots will begin to adhere more to the principles of modern robotics as they begin interacting with the world around them. Students will hopefully begin to imagine new applications for their robots once they begin to understand the EV3 intelligent capabilities. Teachers will use the challenge mats from lesson 3 to test if the robots are able to follow a black line once the programming is complete and the colour sensor is properly in place.


(https://connex.stao.ca/sites/default/files/media/sch-ev3-l6b.jpg)

Timeline	*Teaching Sequence*
6 to 7 hours	[1] Students should begin asking questions about what information a robot might need to allow it to follow a black line or a coloured tag of paper. [2] Students should use prior knowledge from their Grade 4 ‘Understanding Matter and Energy’ unit to recall details regarding the spectrum of colour, and ideas around reflecting and absorbing light. To better understand the sensor that is the focus of this lesson, students should examine this e-resource from LEGO Education [http://bit.ly/ev3-coloursensor (http://bit.ly/ev3-coloursensor)]. To collect ideas regarding the new EV3 coding components, students are encouraged to examine this e-resource from *LEGO Education* [http://bit.ly/ev3-switch (http://bit.ly/ev3-switch)]. If time permits, students can also collect ideas using *LEGO Education* e-resources regarding other sensors that the robot can utilize, such as the ultrasonic sensor [http://bit.ly/ev3-ultrasensor (http://bit.ly/ev3-ultrasensor)], touch sensor [http://bit.ly/ev3-touchsensor (http://bit.ly/ev3-touchsensor)] or gyro sensor [http://bit.ly/ev3-gyrosensor (http://bit.ly/ev3-gyrosensor)]. [3] Teachers may have to guide students through the planning stage to understand the parameters of the EV3 programming conditional statement [*switch* or *if/then* block], and using this e-resource from *LEGO Education* [http://bit.ly/ev3-coloursensor-stopatline (http://bit.ly/ev3-coloursensor-stopatline)] is a good way to get students thinking about programming details. In order for the robot to follow a black-line, the orange *switch* block needs to use the colour sensor to monitor ‘reflected light intensity’, and then operate the motors based on the information the sensor observes. The *switch* block should be placed inside a *loop* block so that the robot will continuously ask itself the *if/then* statement. This will be challenging, but will be so fulfilling once the students code the robot correctly. [4] Students will add the colour sensor to their robot so it is facing down and is between 2mm and 10mm from the surface of the table, attaching the interface cable to port 3 in the control block. When the sensor is mounted effectively, begin generating code so the robot follows a black line. Stress patience and persistence to complete this task. *EV3 FBL code example for teacher use - http://bit.ly/ev3-FBL-code (http://bit.ly/ev3-FBL-code). [5] If time permits, have groups make unique black line challenge mats using electrical tape, foam board, and different types of triangles to map out a design. Then, ask teams to successfully navigate the perimeters of these various mats, which will have a mix of obtuse and acute angles, and will require programming modifications to complete successfully.

Guiding Questions

-What will our CODE look like now that we have added a colour/light sensor?

-How can we use a ‘WAIT’ code block?

-What is a ‘SWITCH’ block or conditional statement?

-Will we have to use a LOOP in our programming?

-How much power should your motors use so the robot is able to follow the black line and travel the perimeter of the shape?

-What is the shape and perimeter of the shape on the challenge mat we are designing? What type of angle will each of the turns be?

By the end of lesson 6, students will understand how to build and program robots. This transferable skill can then be applied to other areas of study, either solving problems directly related to technology or using these resources simply as a means of expressing their ideas or discoveries. Direct extensions will be outlined in the **Future Opportunities / Extensions** below.

Support Resources:

Guided Inquiry / Maker Education Model, Basic Infographic [All lessons]

- http://bit.ly/makered-guidedinquiry (http://bit.ly/makered-guidedinquiry)

Guided Inquiry Model, Extensive Infographic [All lessons]

- http://bit.ly/guidedinquiry-big (http://bit.ly/guidedinquiry-big)

Guided Inquiry / Maker Education Student Document, teacher can add details [All lessons]

- http://bit.ly/makered-guidedinquiry-studentdoc (http://bit.ly/makered-guidedinquiry-studentdoc)

Classroom Catalyst Inquiry Introduction Video

- http://bit.ly/ev3-introvideo (http://bit.ly/ev3-introvideo)

Basic Rig Building Instructions 1 [Lesson 2]

- http://bit.ly/ev3-basic1 (http://bit.ly/ev3-basic1)

Basic Rig Building Instructions 2 [Lesson 2]

- http://bit.ly/ev3-basic2 (http://bit.ly/ev3-basic2)

Video Example of DR 50cm robot [Lesson 3]

- http://bit.ly/ev3-DR-50cm-examplevid (http://bit.ly/ev3-DR-50cm-examplevid)

Sample Code [Lesson 3]

- http://bit.ly/ev3-DR-50cm-code (http://bit.ly/ev3-DR-50cm-code)

Video Example of DR 3part robot turning [Lesson 4]

- http://bit.ly/ev3-DR-3part-turnexamplevid (http://bit.ly/ev3-DR-3part-turnexamplevid)

Sample Code [Lesson 4]

- http://bit.ly/ev3-DR-3part-code (http://bit.ly/ev3-DR-3part-code)

Video Example of DR perimeter robot [Lesson 5]

- http://bit.ly/ev3-DR-pentagon-examplevid (http://bit.ly/ev3-DR-pentagon-examplevid)

Sample Code [Lesson 5]

- http://bit.ly/ev3-DR-cube-code (http://bit.ly/ev3-DR-cube-code)

Video Example of Modern Robots using colour sensors [Lesson 6]

- http://bit.ly/ev3-Smart-coloursensorexamplevid (http://bit.ly/ev3-Smart-coloursensorexamplevid)

Sample Code [Lesson 6]

- http://bit.ly/ev3-FBL-code (http://bit.ly/ev3-FBL-code)

Related Background Resources and/or Links:

Koechlin, Carol et al. (2010), *Together For Learning: School Libraries and the Emergence of the Learning Commons, A Vision for the 21st Century*, Retrieved from http://www.togetherforlearning.ca/t4l-vision-document/ (http://www.togetherforlearning.ca/t4l-vision-document/)

- This Canadian resource provides teachers with a deeper understanding of the guided inquiry approach and collaboration in a 21st learning environment.

Brown, Sharon et al. (2017) *Canada Learning Code Teacher Guide: Introduce Coding to Your Classroom*, Retrieved from http://www.canadalearningcode.ca/canada-learning-code-week/teacher-training.html (http://www.canadalearningcode.ca/canada-learning-code-week/teacher-training.html)

- This Canadian resource gives teachers and students a better understanding of the fundamentals of computer sciences

McDonald, Silver et al. (2018), *LEGO Education Curriculum Resources*, Retrieved from https://education.lego.com/en-us/lessons?pagesize=12 (https://education.lego.com/en-us/lessons?pagesize=12)

- This resource provides teaching and learning opportunities that educators can employ how use with the *LEGO Mindstorms* robotic systems

Special acknowledgments go to Mr. Jesse Campbell OCT and Mr. Kevin Robinson OCT for their collaborative efforts over the past many years in helping to develop and test this robotics unit with students in a makerspace setting.

Assessment Opportunities:

Teachers can be extremely flexible with their assessment decisions during this unit. Often, students are assigned a ‘learning log’ or checklist that can act as a record of their learning throughout the unit [http://bit.ly/ev3-learninglog (http://bit.ly/ev3-learninglog)]. Expectations can be checked off and commented on with the teacher’s approval once students have demonstrated or were asked to demonstrate an ability. In the past, students have been asked to demonstrate their learning through student-teacher conferences, report writing, class presentations, graphs, charts, diagrams, podcasts, journal entries, short videos and digital white-board presentations. The method of assessment is completely at the teacher's discretion in discussion with the student[s] and can be universally applied or highly individualized. Assessment criteria, descriptors and qualifiers were determined by using ideas outlined in Ontario curriculum documents (http://www.edu.gov.on.ca/eng/curriculum/elementary/subjects.html), and were developed as unique assessment opportunities listed above were being developed.

Lesson 1 – Students will have an opportunity to create a triangulated assessment piece to share their ideas about a 'Robot Maker Code-Of-Conduct'. Using a digital whiteboard APP, the group will capture conversations, observations, and product when presenting what they have discovered. Here is an example of this type of triangulated assessment piece from a 2016 grade 6 Space and Earth Systems unit > http://bit.ly/MakerEd-assessment (http://bit.ly/MakerEd-assessment) . Be sure to note that verbal and written participation in this media production can be analyzed thanks to the interface.

Using the ideas above, the teacher can consider evaluating grade 5 'Understanding Structures and Mechanisms – Developing Investigation and Communication Skills', grade 5 'Language – Writing' and grade 5 'Language – Media'.

Lesson 2 – This can be a very open-ended task that will potentially produce a wide variety of robot rigs. Teachers have the opportunity to evaluate designs based on the tensile strength [the resistance of a material to breaking under tension] of the rig while being acted on by various forces, evaluated the accuracy of measurements on student's plans compared to their final creation, or evaluate the types of mechanisms students incorporate into their robot drivetrains.

Using the ideas above, the teacher can consider evaluating grade 5 'Understanding Structures and Mechanisms', grade 4 – 'Understanding Structures and Mechanisms' and grade 5 'Math – Geometry and Spatial Sense'.

Lesson 3 – Students will be asked to apply real-world math to a digital language to make their robot move. Evaluating measurements and making predictions will be an important part of this task. Students have previously written reports to summarize their numeric thinking for assessment.

Using the ideas above, the teacher can consider evaluating grade 5 'Math – Measurement' and grade 5 'Language – Writing'.

Lesson 4 – Students will be asked to use rulers and protractors to gather data, and then apply their findings to their computer programming. Groups can chart levels of torque, distance travelled, and time lapsed.

Groups also have the opportunity to make structural changes to their robot rig to accomplish this task in the shortest time possible. As groups reduce weight while trying to maintain tensile strength, and add gears and fixed pulleys to the drivetrain, teachers have ample opportunity to assess the results.

In the past, students have produced a second media resource similar to what was created during 'lesson 1' to showcase all their discoveries.

Using the ideas above, the teacher can consider evaluating grade 5 'Understanding Structures and Mechanisms' , grade 4 'Understanding Structures and Mechanisms', grade 5 'Math – Measurement', grade 5 'Math – Data Management and Probability', grade 5 'Language – Writing' and grade 5 'Language – Media'.

Lesson 5 – Students measure distances and calculate the perimeters of 2D shapes while gathering information for their computer programs.

Using the ideas above, the teacher can consider evaluating grade 5 ‘Math – Measurement’ and grade ‘Math – Geometry and Spatial Sense’.

Lesson 6 – Groups will have to successfully modify the structure of their robot rigs to accommodate the new components. Students will design challenge mats to test their colour sensor/line follow programs using triangle stencils as a guide. In the past, students have worked to calculate the perimeters of other group’s unique challenge mats, predict what types of triangles make up the new challenge mats [similar to a tangram puzzle] and measure the angles that the unique challenge mat shapes consist of.

Using the ideas above, the teacher can consider evaluating grade 5 ‘Understanding Structures and Mechanisms’ , grade 5 ‘Math – Measurement’ and grade 5 ‘Math – Geometry and Spatial Sense’.

Future Opportunities / Extensions:

Extension 1 – A popular extension in the past has been to design a large scale challenge mat [1.5m x 3m] that bares the characteristics of a region devasted by an earthquake. A popular premise is that the student’s robot is an automated emergency response vehicle meant to locate and transport survivors to the hospital.

Students can assist in the design process, including accurate details about how these types of natural forces would impact a suburban or urban environment. Creating discussion and writing based around these ideas will help accomplish specific expectations 1.1 and 1.2 of the Gr 5 understanding structures and mechanisms unit. Teachers can ensure that the mat has a wide variety of obstacles students need to move or pick up, which would cause students to construct robotic structures or mechanisms [cranes, lift arms, mechanical claws, plow] to solve the problems. Teachers can also include acute and obtuse angle turns [gyro sensor] or walls at different distances [ultrasonic sensor] to incorporate numeracy and get students to experiment with new sensors.

A media piece, similar to what was outlined for ‘lesson 1’ has been submitted in the past to showcase student discoveries and to act as a triangulated assessment piece.


(https://connex.stao.ca/sites/default/files/media/sch-ev3-extension-earthquakezone.jpg)

Extension 2 – Have students organize the robots so they act as XY Plotting Machines. Students can create mounts for markers, pens or pencils, and generate drawings based on programming. For example, using code student’s generated for the perimeter of a pentagon during lesson 5, the robot will draw the shape of a *Plumeria blossom* or other 5 petal flower. Robots can draw pictures or write words based on precise measurements, good planning, and accurate programming. If dark colour, broad markers are available, one robot could draw a path that another robot using the code from lesson 6 could follow using its colour sensor.

Extension 3 – Form a robotics competition team. Take students who performed well with either soft skills or hard skills during the unit to continue tinkering and innovating. A focus for the group is simple, as Canadian competitions, such as *Skills Ontario* or *Zone01 Robotique*, offer students a variety of goals at different EV3 skill levels and exciting academic event days where teams are involved in tournaments. An additional benefit of this type of group as it develops mentors that can act as instructional contributors for other classes learning about computer sciences or robotics.

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subject
out
this
(https://www.facebook...
https://connex.stao...
catalyst/junior-
division-
robotics-
inquiry)

RESOURCES

- Classroom Catalyst Introduction Video (http://bit.ly/ev3-introvideo)
- Student Inquiry Report for each lesson (https://connex.stao.ca/sites/default/files/sch_llc_-_inquiry_student_document_blank.pdf)
- Basic model for learning (https://connex.stao.ca/sites/default/files/guided_inquiry_makered_model_-_basic_0.pdf)

ELEMENT

- Inquiry (/expert-elements/inquiry)

(/classroom-catalysts) RETURN TO CATALYSTS (/classroom-catalysts)

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