The Education Fund
For Excellence in Miami-Dade Public Schools
2018-2019

Idea Packet
The Power of Math in LEGO Robotics

Sponsored by: FPL®
The power of Math in LEGO Robotics

Disseminator: Marco Diez
marcodiez@dadeschools.net
Howard D. McMillan Middle School (Mail Code: 6441)
13100 SW 59 ST. Miami, FL 33183

For information concerning Ideas with IMPACT opportunities including Adapter and Disseminator grants, please contact:

Debra Alamo, Interim Program Manager
Ideas with IMPACT
The Education Fund
305-558-4544, Ext. 105
Email: dalamo@educationfund.org
www.educationfund.org
Table of Contents

Contents
Goals and Objectives ...................................................................................................................... 3
Florida Standards .......................................................................................................................... 4
Lessons 1. Moving forward ............................................................................................................ 5
Lesson 2: Making turns.................................................................................................................. 10
Enrichment. Lesson 3: Motor Rotation Sensor............................................................................. 18
Resources List.................................................................................................................................. 20
Goals and Objectives:

I came up with this idea of using mathematical calculation in my LEGO Robotics class a few years ago. One of the first assignments I gave my students was to make their robot travel a certain distance. I noticed right away that my students started guessing the values on the computer instead of measuring and calculating the exact quantity they needed for the program.

Using mathematical calculations and logic before coding the program is an essential skill that each student should master at an early age. The goal of my project was to apply mathematical reasoning to the programming blocks used in Mindstorms EV3.
Florida Standards:

- Mathematics

Domain: RATIOS & PROPORTIONAL RELATIONSHIPS

MAFS.6.RP.1.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

MAFS.7.RP.1.1: Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.

MAFS.6.RP.1.3: Use ratio and rate reasoning to solve real-world and mathematical problems.

Domain: THE NUMBER SYSTEM

MAFS.6.NS.3.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values.

- Engineering Technology

CTE-TECED.68.ENGTEC.03: Demonstrate understanding and use of measurement tools and systems.
Lessons 1. Moving forward.

Duration/Time Frame: 1 to 3 class periods.

Topics:
- Calculating the circumference of the wheel.
- Understanding the meaning of the circumference of the wheel.
- Using the circumference of the wheel to move forward or backward.

Objectives:
- Calculate the circumference of the wheel.
- Understand the mathematical application of the circumference of the wheel for future calculations.
- Explore different ways to calculate the circumference of the wheel.

Materials:
- Wheels
- Ruler
- Tape
- Computer
- Lego Robot

Procedures and Activities:
- As a class activity, discuss with students the reason finding the circumference of the wheel is essential to calculate the number of rotations the robot needs to travel a certain distance. Students must understand through reasoning that the circumference of the wheel is equivalent to the length traveled after one rotation.
- In small groups, have students explore different ways to find the circumference of the wheel(s). For instance, (a) holding a ruler, students can roll a wheel a full rotation, (b) measure the diameter of the wheel and then use the formula $C=d\pi$, (c) using a piece of thread around the wheel, (d) programming the robot to travel 1 rotation and then measuring the distance traveled, etc.
(a) holding a ruler, students can roll a wheel a full rotation

(b) measure the diameter of the wheel and then use the formula $C=d\pi$

(c) using a piece of thread around the wheel
(d) programming the robot to travel one rotation and then measuring the distance traveled

- (Suggested activity) Set up a simple maze on the floor with electrical tape. Once the distance the robot need to travel is set on the floor, have the students measure to figure out how to calculate the number of rotations their wheels need to travel the entire maze. (Note: Students may still not be able to calculate the required rotations to make turns. Have them estimate those measures unless they want to try calculating the actual values)
Examples:

**Example 1.**
The Circumference of the wheel is 5 in. The distance the robot needs to travel is 30 inches.
Answer: The robot needs to travel 6 rotations

**Example 2.**
The Circumference of the wheel is 6.9 in. The distance the robot needs to travel is 30 inches.
Answer: The robot needs to travel about 4.35 rotations
- Reflection activity. Have students reflect on the applications of using mathematical calculations to program their robots to move forward.

- (Suggested Activity) Formative assessment.

Have students answer the following questions the next day:
1. How many inches will your robot travel after four rotations? (Note: The diameter of the wheels is 3.2 inches)
2. How many rotations will this same robot need to travel 120 inches?
Lesson 2: Making turns.

Duration/Time Frame: 1 to 3 class periods.

Topics:
- Calculating the swing and point turns.
- Understanding the meaning of the distance between the robot’s wheel.

Objectives:
- Calculate the swing and point turns.
- Explore the differences between the swing and point turns.
- Apply the mathematical calculations when programming the robot.

Materials:
- Wheels
- Ruler
- Tape
- Computer
- Lego Robot

Procedures and Activities:
- As a class, discuss with students the differences between the swing and point turns. (In the swing turn, one of the wheels remains off while the other wheel moves either forward or backward to complete the turn. In the point turn, both wheels move, one moves forward while the other one moves backward)
In the swing turn, one of the wheels remains off while the other wheel moves either forward or backward to complete the turn.
In the Point turn, one wheel moves forward while the other one moves backward.
- In a small group, students will calculate both the swing and point-turn having different scenarios of robots and wheel sizes. (see examples)
- Examples 1 and 2 using the swing turn.

**Example 1: Use the swing turn**

The circumference of the robot’s wheels is 8 in
The distance between the wheels is 5 in
Calculate a 90 degree turn of this robot.

Circumference of Circle = \( \pi \times d \)
\[ = 3.14 \times 10 \]
\[ = 31.4 \text{ inches} \]

\[
\frac{\text{Circumference of Circle}}{\text{Circumference of the wheel}} = \frac{31.4}{8} = 3.93 \text{ rotations}
\]

Meaning = The robot will travel a full circle after 3.93 rotations

To calculate the rotations needed for 90 degrees:

\[
\frac{90}{360} = \frac{1}{4}\quad \text{now,} \quad \frac{1}{4} \times 3.93 = 0.98 \text{ rotations}
\]

Answer: The robot will turn 90 degrees with 0.98 rotations

*Note: The Swing Turn could be done using the Move Tank block or the Large Motor block.*
Example 2: Use the swing turn

The circumference of the robot’s wheels is 5.5 in
The distance between the wheels is 4.2 in
Calculate a 30 degree turn of this robot.

Circumference of Circle = π*d
= 3.14*8.4
= 26.4 inches

\[
\frac{\text{Circumference of Circle}}{\text{Circumference of the wheel}} = \frac{26.4}{5.5} = 4.8 \text{ rotations}
\]

Meaning = The robot will travel a full circle after 4.8 rotations

To calculate the rotations needed for 30 degrees:

\[
\frac{30}{360} = \frac{1}{12} \quad \text{now,} \quad \frac{1}{12} \times 4.8 = 0.4 \text{ rotations}
\]

Answer: The robot will turn 30 degrees with 0.4 rotations

Note: The Swing Turn could be done using the **Move Tank** block or the **Large Motor** block.
- Examples 3 and 4 using the point turn

Example 3: Use the point turn

The circumference of the robot’s wheels is 7 in
The distance between the wheels is 6.2 in
Calculate a 45 degree turn of this robot.

Circumference of Circle = $\pi * d$

$= 3.14 * 6.2$

$= 19.5$ inches

\[
\frac{\text{Circumference of Circle}}{\text{Circumference of the wheel}} = \frac{19.5}{7} = 2.79 \text{ rotations}
\]

Meaning = The robot will travel a full circle after 2.79 rotations

To calculate the rotations needed for 45 degrees:

\[
\frac{45}{360} = \frac{1}{8} \text{ now, } \frac{1}{8} * 2.79 = 0.35 \text{ rotations}
\]

Answer: The robot will turn 45 degrees with 0.35 rotations

\[\text{Example 3: Point Turn} \]
\[\text{Using the Move Tank Block} \]
\[\text{Notice that the motor on B goes backwards while the motor on C goes forward} \]

Note: The Point Turn must be done using the Move Tank block
Example 4: Use the point turn

The circumference of the robot’s wheels is 10 in.
The distance between the wheels is 4 in.
Calculate a 127 degree turn of this robot.

Circumference of Circle = \( \pi d \)
= 3.14 \* 4
= 12.56 inches

\[
\frac{\text{Circumference of Circle}}{\text{Circumference of the wheel}} = \frac{12.56}{10} = 1.26 \text{ rotations}
\]

Meaning = The robot will travel a full circle after 1.26 rotations

To calculate the rotations needed for 127 degrees:

\[
\frac{127}{360} \times 1.26 = \frac{16}{45} \times 1.26 = 0.45 \text{ rotations}
\]

Answer: The robot will turn 127 degrees with 0.45 rotations

Note: The Point Turn must be done using the Move Tank block.
- (Suggested Activity) Formative assessment.
  Have students answer the following questions the next day:

1. James and Tyler are programming their Lego robot. The distance between the wheels of the robot is 4.5 inches. If they are using wheels with a diameter equal to 2.4 inches, calculate the number of rotations they need to make the robot turn 45 degrees? (Note: Solve the problem for both types of turns)
Enrichment. Lesson 3: Motor Rotation Sensor

Lesson 3: Using the Motor Rotation Sensor (Enrichment Lesson)

Duration/Time Frame: 1 to 2 class periods.

Topics:
- Using the Motor Rotation Sensor.
- Programming the Wait block.

Objectives:
- Create simple programs using the Motor Rotation sensor.
- Evaluate different ways to program the robot.

Materials:
- Computer
- Lego Robot

Procedures and Activities:
- Once the Motor Rotation sensor is introduced, students should be challenged to create and evaluate different ways to program the robot to accomplish the same tasks.
- (Suggested Activity). Challenge students to develop and evaluate a program that performs the same task as the ones from Lesson 1, but this time, using the Motor Rotation Sensor (Examples 1, 2, and 3)

- Answers:

![Example 1: The robot needs to travel 6 rotations](image)
- Reflection: Students should reflect on these other ways to solve the same tasks using the Motor Rotation Sensor.
- Conclusion: Challenge students to find different ways to program the robot to accomplish the same tasks *(Hint: Using other blocks such as the Loop or Switch blocks)*
Resources List

LEGO Mindstorms EV3 Software.


Student-ready resources, teacher support, assessment tools, sample programs, and building instructions.

Contributors with **IMPACT**

**Platium Star**

- Ford Motor Company Fund

**Gold Star**

- TD Bank
- Assurant
- P.L. Dodge Foundation
- Iris Smith
- FPL
- Miami Marlins

**Silver Star**

- Learning A-Z
- Perez Trading Company
- MBF Miami Bayside Foundation

**Bronze Star**

- Raj Rawal and Anne Marie Miller Memorial Foundation
- Robert Russell Memorial Foundation
- Jack Chester Foundation
Apply for an Ideas with IMPACT Adapter Grant!

All Miami-Dade County public school teachers, media specialists, counselors, or assistant principals may request funds to implement any project idea, teaching strategy, or project from the 2018 Idea EXPO workshops and/or curriculum ideas profiled annually in the Ideas with IMPACT catalogs from 1990 to the current year, 2018-19. Most catalogs can be viewed on The Education Fund’s website at educationfund.org under “Ideas with IMPACT Catalog Publications.”

- Open to all K-12 M-DCPS teachers, counselors, media specialists
- Quick and easy reporting requirements
- Grants range from $150 - $400
- Grant recipients recognized at an Awards Reception

To apply, you must contact the teacher who developed the idea before submitting your application. Contact can be made by attending a workshop given by the Disseminator, communicating via email or telephone, by visiting the Disseminator in their classroom, or by having the Disseminator visit your classroom.

Project funds are to be spent within the current school year or an extension may be requested. An expense report with receipts is required by Monday, June 3, 2019.

APPLICATION DEADLINE: December 13, 2018

Apply online at educationfund.org

For more information, contact:
Audrey Onyeike, Program Director
305.558.4544, ext. 113
audrey@educationfund.org