

LOG OUT



Use headphones for the best experience

EXPEDITION  
**ATLANTIS**  
A CALCULATED DEEP SEA ADVENTURE

## iPad Teacher Guide

Using the engaging nature of

# ***Robotics Exploration***

to teach students skills in  
proportional reasoning

## Table of Contents

3	FAQ
4	Checklist
<b>5</b>	<b><u>Introduction</u></b>
	Why Expedition Atlantis?
6	What is Proportional Reasoning?
7	In the Classroom
8	Suggested Weeklong Pacing
9	Introducing the Game
	Method 1 - with Smartboard
	Method 2 - After Students Explore
	Method 3 - Traditional
11	Leading Group Discussions
13	Immediate Feedback
14	Differentiated Instruction
<b>15</b>	<b><u>Game Mechanics</u></b>
15	Learn How To Setup the Game
16	Installation, System Requirements, Optimizing Your Computer's Performance
17	Log in
18	Settings
19	Customizing Difficulty
20	Select Level
21	Chapter 1: Distance
22	Chapter 2: Turning
23	Chapter 3: The Robot Garage
24	Chapter 3: Turning and Straight
25	Chapter 4: Solving Atlantis
26	Quick Travel Tool
27	Moving Forward Training
28	Turning Training

## **29 Teacher Resources**

29	Common Misconceptions: Magical Doubling
30	Common Misconceptions: Additive Error
31	Common Misconceptions: Incorrect Build-up
32	Abstraction Bridge and Extension Activities

## **Reproducibles**

34	Chapter One Worksheet
35	Robot Movements Question 1
36	Robot Movements Question 2
37	Robot Movements Question 3
38	A New Robot! Question 1
39	A New Robot! Question 2
40	A New Robot Question 3
41	Going on a Trip Question 1
42	Going on a Trip Question 2
43	Going on a Trip Question 3
44	Tire Upgrade Problems
47	Plow Upgrade Problem
48	Wheel Size Problem
49	Price Problems
50	Size Problems
51	Paint Mixing Problems
52	Density of Tire Spike Problem

## **Appendix**

53	Lesson Plan Outline for Elementary
54	Lesson Plan Outline for Middle School
55	Individualized Education Plans
56	High Engagement
57	Research Driven
58	Common Core Standards

# FAQ

## Before using Expedition Atlantis

- ▶ Will Expedition Atlantis help me to teach to Common Core Math Standards?  
See “Common Core Standards” on page 58
- ▶ How do I Log into the game?  
See “Log In” on page 17.
- ▶ How do I use the game to teach proportional reasoning?  
See “In The Classroom and Suggested Weeklong Pacing” pages 7 - 10.
- ▶ How will my students learn to play the game?  
The game is intuitive, and teaches students how to play the game in the game.
- ▶ What do I need to prepare for class?  
See “Checklist” on page 4.
- ▶ What’s the lesson structure?  
See “In the Classroom” pages 7 - 10.
- ▶ What difficulty level should I set for my students?  
See “Differentiated Instruction” page 14.

## During class

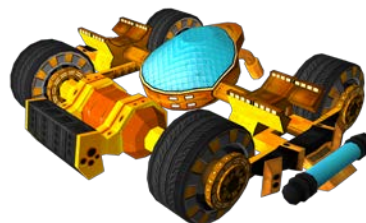
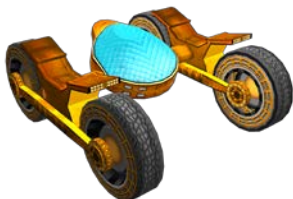
- ▶ How do I introduce Expedition Atlantis to my class?  
See “Introducing the game” on page 9.
- ▶ How do I help students with the problems?  
See “Leading Group Discussions” on page 11
- ▶ How do I end class each day?  
See “Abstraction Bridges” on page 32.

## After class

- ▶ What’s the feedback I should be looking for?  
See “Immediate feedback” on page 13
- ▶ How do I talk about proportions beyond this game?  
See “Extension Activities” on page 32.

# Checklist

- Become familiar with the game**  
Play the game at different levels. Become familiar with the Movement Simulator and the feedback screens. The game is intuitive and you will be able to play the game by simply logging in, but you can learn about all of the game features in the Game Mechanics Section of this guide. (See pages 15 - 28, Game Mechanics)
- Be ready to teach your students how to log in**  
(see page 17, Log In)
- Determine the pacing for the lesson**  
(see page 7, In the Classroom, and pages 8 - 9, Suggested Weeklong Pacing)
- Learn how Expedition Atlantis emphasizes a mechanistic understanding**  
of proportional relationships instead of a calculation method (see page 57, Research Driven, and pages 27 -28, Moving Forward and Turning Training)
- Review suggested questioning techniques**  
(see page 11, Leading Group Discussions)
- Review the reproducible pages**  
that are available in the Teacher's Guide (see pages 32 - 52, Abstraction Bridges and Extension Activities)
- Determine your students' proper level of difficulty**  
Have level of difficulty selected for each student (see page 14, Differentiated Instruction, and page 19, Customizing Difficulty Level)



## Why Expedition Atlantis

Expedition Atlantis presents mobile robot math problems in a highly scaffolded and contextualized manner to motivate students to use math rather than “guess and check” their way through robot programming. The game is designed so that students focus on learning mathematical strategies without having to worry about the nuances of programming. Expedition Atlantis’ rewards students for mathematical solutions, and the tools provided in this teacher guide are designed to generalize students’ proportional reasoning skills by the end of the game.



## When to use Expedition Atlantis

Expedition Atlantis requires students to calculate a robot’s straight and turning movements as they solve the riddle of Atlantis and is appropriate for math, science, or robotics classrooms. If you are using this game in a math or science lab, then the right time to use it is when you are introducing students to proportionality. If you are using this game in a robotics classroom, use it when students are learning to control basic mobile robot movement so that they quickly learn that they can use math to control their robot! The game is appropriate for use in younger grades where some students may need acceleration, and in older grades where students may need remediation.

## How to use Expedition Atlantis

This game is designed to be used in combination with short teacher led discussions, and the abstraction bridge handouts found at the end of this teacher guide. The handouts are designed to provide teachers with formative assessment opportunities and to generalize a student’s mathematical understanding. Consider the Lesson Plans presented on the next few pages: one version uses Expedition Atlantis to introduce the topic of Proportionality to new learners, while the other uses it as a review with more experienced students.

# What is Proportional Reasoning?

Proportional reasoning is used everywhere, and so it is critical that all students can think and reason proportionally.

*Proportional reasoning - "On the one hand, it is the capstone of children's elementary school arithmetic; on the other hand, it is the cornerstone of all that is to follow." -Lesh, Post and Behr 1988*

## Daily economics

- Which is the better buy, 1 kg of butter that costs \$3.50 or 1.5 kg that costs \$4.20?



## Robotics

- I know that if I turn my robot's wheels 5 times it move 6m. How far should it go if I want to turn some number of rotations  $x$ ?



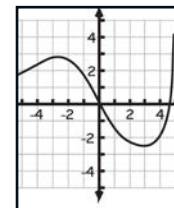
## Daily geography

- The map on my phone shows half a mile as  $\frac{3}{4}$ in. How far is it to go about 3in worth of distance on the map?



## Algebra

- What is the rate of change in the equation  $y=13x+7$ ?



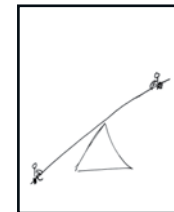
## Daily cooking

- I found a recipe for 18 cookies:
  - $\frac{2}{3}$  cup butter, softened
  - $\frac{3}{4}$  cup sugar
  - 1 teaspoon baking powder
  - $\frac{1}{4}$  teaspoon salt
  - 1 egg
  - 1 tablespoon milk
  - 1 teaspoon vanilla
  - 2 cups all-purpose flour
- What do I put in to make 2 dozen cookies?



## Physics

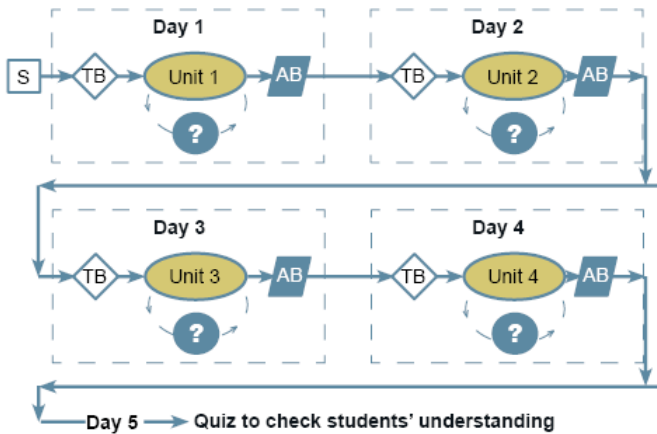
- Two kids are playing on a seesaw. One kid weighs 80 pounds and sits 8ft from the fulcrum. The other kid only weighs 40 pounds - how far away from the fulcrum should she sit to balance the seesaw?



## References



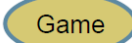


Lesh, R., Post, T., & Behr, M. (1988). Proportional reasoning. In J. Hiebert & M. Behr (Eds.), *Number Concepts and Operations in the Middle Grades* (Vol. 2, pp. 93-118). Reston, VA: National Council of Teachers of Mathematics.

## In the Classroom



### Lesson Outline

#### Symbol Legend

-  Setup - The classroom and computers are ready. See page ii checklist.
-  Teacher Briefing - an opportunity for teacher to set the stage for today's class
-  Students play the game! The teacher observes students' progress and addresses individual and group questions as needed.
- 
-  Abstraction Bridge Word Problems - A time for students to demonstrate and generalize their math understanding.

Pictured at the left is a graphical representation of a one-week lesson outline.

Elementary School Students will require more teacher intervention. According to the Common Core Mathematics Standards, Operations and Algebraic Thinking, Number and Operations in Base Ten, Number and Operations - Fractions, and Measurement and Data are introduced in grades three, four, and five. Decimals are not formally introduced until grade five. Expedition Atlantis can be used to reinforce these grade appropriate math topics.

This game is designed to teach proportional reasoning which is introduced in grades six and seven. Older Students should be able to work their way through the game with less mediation.

*In order for the game to effectively reinforce a student's ability to think proportionally, teachers will need to foreground the math, allow students to talk about and reason with it, and then measure student's learning by testing.*

Abstraction Bridge Word Problems (starting on page 32) are specifically designed to help teachers to foreground and generalize the math found in the Expedition Atlantis Game.

*Proportionality is introduced in grade six and again in grade seven but research has shown that students and adults struggle with proportional reasoning.*

# Suggested Weeklong Pacing

*The following pacing guide is an example starting point for customizing Expedition Atlantis to meet your students' needs.*

## Day 1

Anticipatory Set - A Teacher Briefing (5-10 min, see "What is Proportional Reasoning" on page 6)

Gameplay (20-25 min, self-paced, handout page 34)

Group discussion (10-15 min, see page 11)

Day 1 Have students complete the "Robot Movement" Word Problems from Reproducible Section, pages 35 - 37. Any work not completed is to be completed for homework. **Note: Younger students may need more guidance with these questions and so the lesson may take a bit more time. Some problems are easier solved using a rate strategy and others a scaling strategy.**

### *Expedition Atlantis Abstraction Bridge Word Problems*

Starting on page 32 there is a section called "Word Problems and Extension Activities". The word problems and extension activities provide the teacher with assessment tools that are also designed to extend student's learning.

## Day 2

Anticipatory Set - Review the Robot Movement Word Problem solutions from Day 1 (5-10 min) or another teacher selected word problem.

Gameplay (30-35 min, self-paced)

Day 2 Have students complete one "A New Robot" Word Problem from Reproducible Section, pages 38 - 40. Any work not completed is to be completed for homework. **See note above.**

## Day 3

Anticipatory Set - Review the New Robot Word Problem solutions from Day 2 (5-10 min) or a teacher selected word problem.

Gameplay (30-35 min, self-paced)

Day 3 Have students complete the "Going On A Trip" Word Problems from Reproducible Section pages 41 - 43. Any work not completed is to be completed for homework. **See note above.**

## Day 4

Anticipatory Set - Review the "Going On A Trip" Word Problem solutions from Day 3 (5-10 min)

Gameplay (30-35 min, self-paced)

Day 4 Have students complete teacher selected Word Problems from the Extension Activity section of this guide (pages 44 - 52). Any work not completed is to be completed for homework. **These questions are a mix of proportional reasoning problems designed to generalize a student's mathematic understanding of proportionality. Some questions may be advanced for younger students.**

## Day 5

Review the results of the "Extension Activity Word Problems".

If applicable, give students a test on applicable mathematics based on what the teacher foregrounded during the lesson (not included)



# Introducing the Game

## Method 1 - Introduce Expedition Atlantis with Smartboard

1. Tell students that they will be beginning a game in which they will need to use math to help their robot reach Atlantis.
2. Open Expedition Atlantis program on your smartboard or projector.
3. Open up the Supplementary Media link “THE CRASH” in Atlantis (see page 18 to see the location of Atlantis’s Supplementary Media) and watch the interactive video with your students.
4. Work your way through a couple of problems with your students, have students solve several problems as a group. Ask them to explain: [How did you get that answer?](#) Also ask: [Did anyone else solve the problem differently.](#) Provide plenty of time for students to explain their answers.
5. Let students begin Expedition Atlantis individually.
6. Circulate around the room
7. Distribute Day One Word Problems, assign unfinished problems for homework. Begin the next day’s class by reviewing the students’ work. **In order to insure student math thinking (and not just guessing) make sure that they not only provide the answer, but also describe how they got their answer using words and pictures.**

## Method 2 - Introduce Expedition Atlantis after students explore game

1. Tell students that they will be beginning a game in which they will need to use math to help their robot reach Atlantis.
2. Let students play Expedition Atlantis for approximately 20-25 minutes independently
3. Circulate around the room
4. At the conclusion of that time ask students the following: [What was the game asking you to do?](#)

Follow up with an additional question: [If you know the following: A robot moves 16 meters in 4 rotations. If it has the same wheels, how far will it move in 9 rotations?](#)

Ask students to illustrate and explain how they solved the problem. Ask students to share both their answer and how they found their answer. Answer: 36m

Extend the thinking. [If I had the robot move 13 meters in 4 rotations, how far will it move in 7 rotations?](#) This question could pose as a think-pair-share question with students working on it and then presenting.) Answer: 22.75 meters

[Is there a way that unit rate would help you in either problem?](#)

[Is there a way the scaling factor could help you in either problem?](#)

5. Distribute Day One Word Problems, assign unfinished problems for homework. Begin the next day’s class by reviewing the students’ work. **In order to insure student math thinking (and not just guessing) make sure that they not only provide the answer, but also describe how they got their answer using words and pictures.**

### Method 3 - Introduce Expedition Atlantis Through Direct Instruction

1. Share with your students that you will be starting a week long unit focusing on proportional reasoning utilizing a computer game called Expedition Atlantis.
2. As a review to proportional reasoning, informally begin having students discuss unit rates and size change factors.

For example:

Unit Rate: If Joe purchases six cans of cola for \$ 4.20, based on all of the cans having the same rate, what would the cost be for one can? Students have just found the unit rate.

Size Change Factor/Scale Change: If I planted a tree that was 3 feet, and the next year it was six feet, what is the scale factor?

If I made a model car that was 2 feet and the actual car was 12 feet, what was the scale factor?

Extend the questioning into movement.

My car is traveling 60 miles an hour. How many miles did I go in three hours?

Prompt students what the unit rate is by setting up this proportion on the board:

$$\frac{\text{miles}}{\text{hour}} = \frac{60}{1} \times \frac{x}{3}$$

Tell students that they have now set up a proportion. This is an example of a missing value proportion.

Prompt students to point out what the unit rate is, as well as the scale/size change factor.

3. Have students begin Expedition Atlantis and circulate around the room.
4. Distribute Day One Word Problems, assign unfinished problems for homework. Begin the next day's class by reviewing the students' work. **In order to insure student math thinking (and not just guessing) make sure that they not only provide the answer, but also describe how they got their answer using words and pictures.**

### Common Student Misconceptions

There are resources that show common student misconceptions on the following pages:

1. Page 29 - Magic Doubling
2. Page 30 - Additive Error
3. Page 31 - Incorrect Build-Up

# Leading Group Discussions

*A script for teachers helping students (extended script on right)*

- Recommended materials: graph paper or manipulables.
- Sample question (based on Chapter 1): Your robot moves 10m in 4 wheel rotations. How many rotations do the robot's wheels need to turn to move 30m?

## 1. Identify the goal

(Extended script)

T: What are we trying to find out in this problem?

T: What are we trying to find out in this problem?

S: How many rotations needed to move 30m

S: Rotations

T: Rotations for what? Rotations to move 100m? Rotations to move 50m?

S: Rotations to move 30m.

T: Right. That's our whole distance - 30m.

## 2. Identify the reference ratio

T: Okay, now what's the reference ratio that's already given to us in the problem?

T: Okay, now what's the reference ratio that's already given to us in the problem?

S: 10m in 4 wheel rotations.

S: 10m in 4 wheel rotations.

## 3. Divide the known similar parts to find the scaling factor

T: Let's break the whole distance of 30m into groups of 10m. See how 30m and 10m are the same units? We have to use the same units when we break something down. So how many groups of 10m go into 30m?

T: Let's break the whole distance of 30m into groups of 10m. See how 30m and 10m are the same units? We have to use the same units when we break something down. So how many groups of 10m go into 30m?

S: 3 times.

S: I don't know.

T: Alright, let's draw it out. Mark 30 blocks on the graph paper...



## Leading Group Discussions (cont.)

Note: For non-integer answers, make sure that the remainder is put into a fraction with the group size (not the total distance) as the denominator, e.g.  $\frac{3}{10}$ , not  $\frac{3}{30}$

Note: For large numbers, remind students that they used division to find the scaling factor. Then say that it's the same process here, but with different numbers.

T: Let's break the whole distance of 30m into groups of 10m. See how 30m and 10m are the same units? We have to use the same units when we break something down. So how many groups of 10m go into 30m?

S: *I don't know.*

T: Alright, let's draw it out. Mark 30 blocks on the graph paper...

T: Okay, now circle your first 10 blocks... That's one group of 10m.

T: Circle the next 10 blocks... that's the 2nd group of 10m. Can you see it now? How many groups of 10m make up 30m?

S: 3.

T: Great. There are 3 groups of 10m in 30m.

### 4. Multiply the scaling factor by the similar number in the reference ratio

T: Great, so we have 3 groups of 10m, and each group takes how many rotations?

S: *4 rotations.*

T: So that's how many rotations total?

S: *12 rotations to move 30m.*

T: Right. That number that you multiply - the 3 - is called the scaling factor, because the meters get multiplied by that amount and the rotations get multiplied by that same amount. And they get scaled by the same amount because the relationship between distance and number of wheel rotations is proportional.

T: And we know that each group of 10m has how many rotations?

S: 4.

T: Right, so label each group of 10m with "4" for how many rotations it takes...

T: Look, you have 3 groups of 4 rotations. How would you figure out what 3 groups of 4 is?

S: *4+4+4?*

T: You could, but what if you had 20 groups of 4? Is there an easier way of solving it?

S: *Oh, multiply.  $4 \times 3 = 12$ .*

T: 12 what?

S: *12 rotations.*

T: To move how far?

S: *30m.*

T: Right. That number that you multiply - the 3 - is called the scaling factor, because the meters get multiplied by that amount and the rotations get multiplied by that same amount. And they get scaled by the same amount because the relationship between distance and number of wheel rotations is proportional.

# Immediate Feedback

*Expedition Atlantis provides teachers the tools to make data based decisions while also providing a clear picture of student progress.*

## Informed Classroom Decisions

- ▶ The Expedition Atlantis Badge system allows teachers to track individual student progress and collect student data as it pertains to:
  - Student progress toward completion of Expedition Atlantis
  - Student average of completed sections of Expedition Atlantis
- ▶ Feedback from the Word Problems where students are required to expose how they think about the problem enables the teacher to quickly identify misconceptions.



Expedition Atlantis includes over 25 contextualized Word Problems designed to reinforce student learning.

## Clear picture of student progress

- ▶ CS2N uses a badge-based system to motivate students, help them to define pathways and set goals, and indicate that they have mastered concepts. Teachers can create a group for their class in CS2N, which will allow them to easily check on their students' progress as they play Expedition Atlantis. CS2N has step by step tutorials to show teachers how to create their own groups and how to access student badges. For more information, please see here: <http://www.cs2n.org/teachers/groups>
- ▶ Students and teachers can see their badges either by clicking on the "Badges" button on the Log In screen, or by looking at each level on the home screen.

## Differentiated Instruction

*The learning environment within Expedition Atlantis is dynamic, allowing students to think about proportional reasoning problems at their current proficiency level, whether that's beginner or advanced.*

### Teacher-led differentiation

- ▶ Teachers can select from 3 preset difficulty levels and have the ability to customize levels at their discretion using controls built into the game.



CADET    EXPLORER    ADMIRAL    CUSTOM

CADET Level uses all whole numbers and provides a very easy to understand level to introduce students to the game.

EXPLORER Level uses a combination of whole numbers and easy to understand rational numbers (i.e. 1.50, 2.25, 3.50). **This is the default difficulty level, based on skills Common Core expects students to have mastered by the time they encounter Proportionality.**

ADMIRAL Level uses two decimal rational numbers.

CUSTOM Level enables the instructor to modify levels to meet their student's needs. (See page 19 to learn more about Customizing Levels)

### Multiple entry points to interact with the game problems

Teachers have option on how to show their students to solve the problems.

- ▶ Answer box can be used as a calculator

The picture at the right shows that a student can type an equation directly into the answer box (74.4/20).



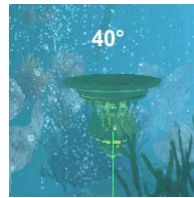
- ▶ Physical calculator - If the teacher prefers they can have their students use calculators.
- ▶ Pencil and paper - See the "Chapter One Worksheet" on page 40.
- ▶ Activating students' prior knowledge by using mental operations

# Learn How To Setup and Navigate the Game



## Installation

*Set up the game on your school's computers. p 16*



## Chapter 2

*Turn a given number of degrees. p 22*



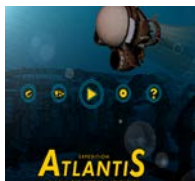
## Log in

*Log in to the game to store user progress. p 17*



## Garage

*Outfit your robot with upgrades. p 23*



## Settings

*Learn how to setup the game to optimize performance. p 18*



## Chapter 3

*Turn and move to retrieve supplies and earn upgrades. p 24*



## Customize

*Setup difficulty levels for your students. p 19*



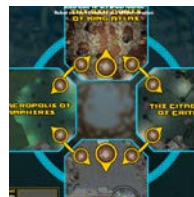
## Chapter 4

*Solve the riddle of Atlantis! p 25*



## Select Level

*Start the game and select levels when you return. p 20*



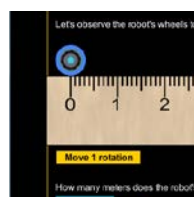
## Quick Travel

*Learn to unlock rooms and travel quickly. p 26*



## Chapter 1

*Move a given distance. p 21*



## Movement Simulator

*Learn about straight and turn movements. p 27 - 28*





# Log In



*This is the first screen that you see when you open the game. How you log in determines how your progress is saved. Teach your students how to save their progress.*

## 1 Log into CS2N

If a teacher wants to track all of her students' progress on one screen, then they will want their students to setup CS2N accounts. When students log in with their own CS2N account, their progress is tracked and stored via the CS2N network. This lets students continue their progress, even on a different computer.

Create a CS2N account at <http://www.cs2n.org/signup> (users will need an email address)

For teachers to see all of their student's progress they will need to setup a CS2N Group. Learn more at [www.cs2n.org/teachers/groups](http://www.cs2n.org/teachers/groups)

## 2 Log in locally

A local log in allows students to save their progress on a local machine. Students will need to use the same computer every day to take advantage of this feature.

## 3 Log in as guest

Within the LOCAL button, there is an option to log in as guest. Logging in as a guest allows teachers to preview and demonstrate the game easily, but once the game is closed no progress will be saved. This option should not be used with students, as all progress will be lost if the application is closed, even accidentally.

## 4 Log in

When a user selects to log in the interface moves to the top of the screen and the keyboard appears.

# Settings



After logging in, you have several options to configure the game

## 1 Supplementary Media

Replay the introductory videos



## 2 Badges

Shows the badges that the player has collected.



## 3 Play

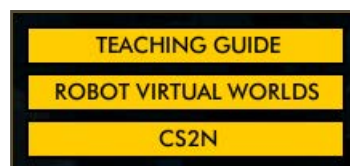
Begins playing the game.

## 4 Settings

Allows you to adjust the game based on the speed of your computer processor.



## 5 Links to Additional Resources



## 6 Log out

Returns the user to the login screen allowing another student to log in.

## Customize Difficulty Level



After logging in, you have several options to configure the difficulty of the game for your students.

### 1 Customize the Problem Types in Chapter 1

Select the number of Basic, Intermediate, and Challenge problems found in Chapter 1

### 2 Customize the Problem Types in Chapter 2

Select the number of Basic, Intermediate, and Challenge problems found in Chapter 2

### 3 Customize the Problem Types in Chapter 3

Modify the types of problem sets found in Chapter 3. The current level is "ALL BASIC PROBLEMS".

### 4 Customize the Reference Values Found in the Game

This opens the displayed box, allowing teachers to differentiate instruction on an individual basis. The default level is INTERMEDIATE VALUES.

# Select Level



## 1 Chapter 1

Players program their robot to move forward precisely, from rock to rock, so ocean storms don't blow them off a cliff.

## 2 Chapter 2

Players program their robot to turn to align with the floating platforms enabling them to jump across an ocean trench on their way to Atlantis.

## 3 Chapter 3

Players program their robot to turn and move, catching valuable upgrades before venturing into Atlantis.

## 4 Chapter 4

Players collect jewels in Atlantis, winning the game when they reactivate the geothermal energy generator.

## 5 Moving Forward Training

Players learn a mechanistic approach to break things into proportions. They are encouraged to use this approach as they clarify and strengthen their thinking about proportions. (Players are also brought here automatically when they have trouble during regular gameplay.)

## 6 Turning Training

Players learn about turning and degrees here.

## 7 Garage

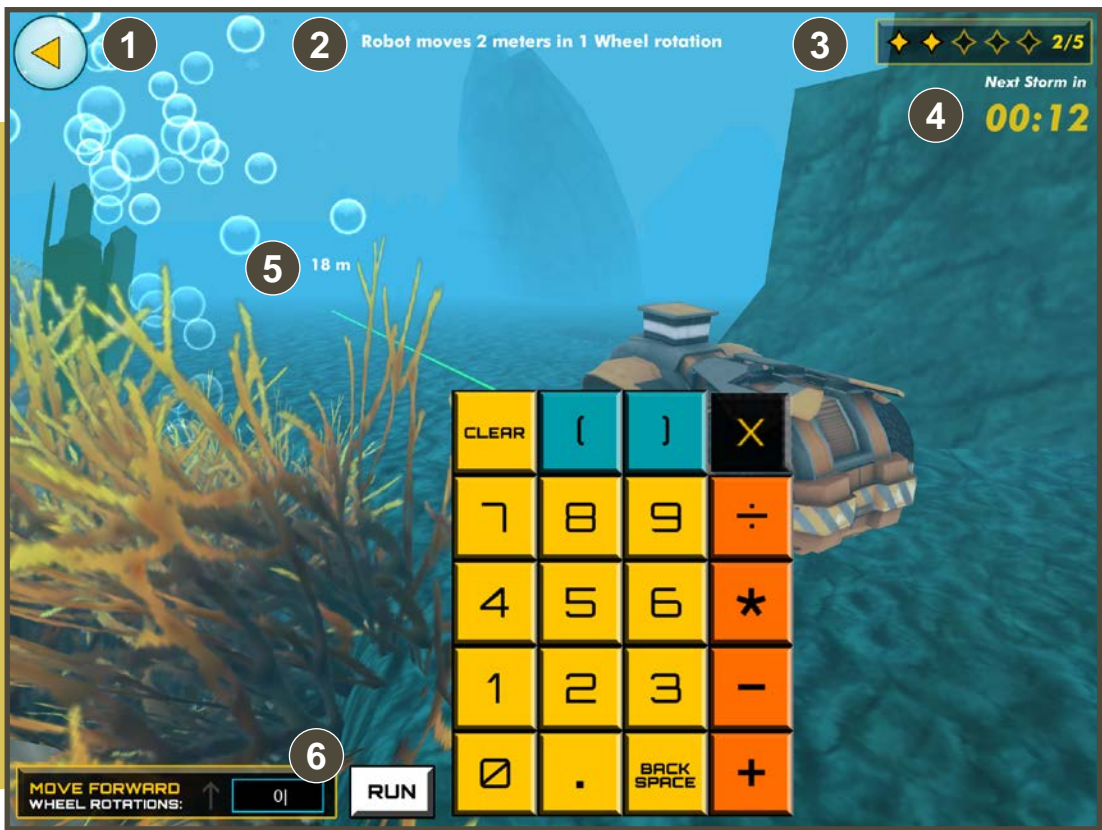
Available after completing Chapters 1 and 2. Players equip their robot with upgrades earned during Chapter 3.

## 8 Difficulty level

Adjust the difficulty of the calculations encountered during gameplay.

## 9 Help Screen

# Chapter 1: Distance



## 1 Back button

Returns players to the home screen

## 2 Reference ratio

Gives players an initial ratio of distance to wheel rotations which allows the player to scale that ratio to different distances. Here, the reference ratio is the unit rate – the distance per 1 rotation

## 3 Skill-meter

Tracks a player's progress. Once all 5 icons are filled, the player moves to chapter 2.

## 4 Storm timer


Indicates when the next underwater storm will be. Players should enter their answer when there is enough time to make it to the next rock. If players give the wrong answer, their robot will be swept away by the storm.

## 5 Goal

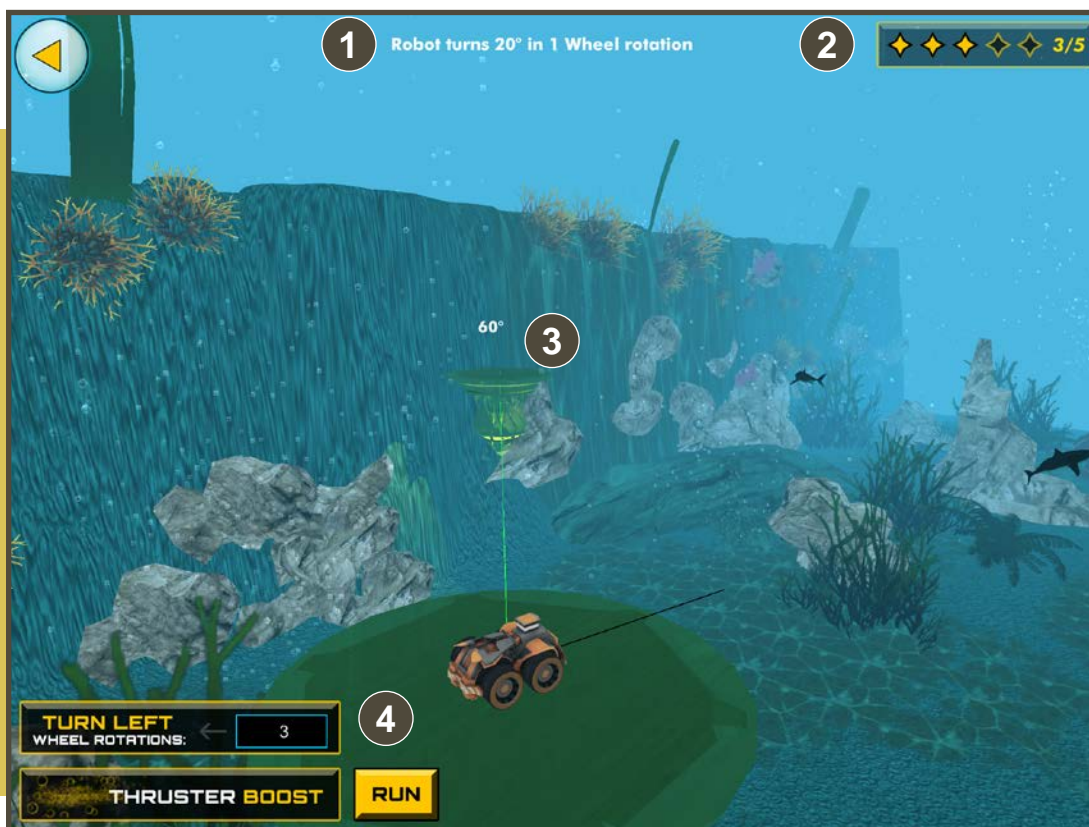
Distance in meters the robot needs to travel in order to avoid the storm current. Players should apply the reference ratio to determine the correct number of wheel rotations to enter in the answer box. In the example above the distance is 16 meters and the reference value is 2meters per wheel revolution. If the robot undershoots or overshoots the goal the robot could be carried away by the storm and the player will need to restart.

## 6 Answer box

Players enter the number of wheel rotations that the robot should move to exactly reach the goal. Decimals and fractions are accepted. The system rounds to 2 decimals. Algebraic expressions are also accepted. In the example above the player could type  $16/2$  into the answer box.

	6.R.P.A.1	MP1	MP6
	6.R.P.A.2	MP2	MP7
	6.R.P.A.3	MP4	MP8
	7.R.P.A.3		

# Chapter 2: Turning



## 1 Reference ratio

Gives players an initial ratio of degrees to wheel rotations, which allows the player to scale that ratio to different distances. Here, the reference ratio is the unit rate – the degrees per 1 rotation

## 2 Skill-meter


Tracks a player's progress. Once all 5 icons are filled, the player moves to chapter 3.

## 3 Goal

Distance in degrees the robot needs to turn in order to align with the target, mesa-like island. Players should apply the reference ratio to determine the correct number of wheel rotations to enter in the answer box. Notice, for negative values, the robot needs to turn left whereas with positive values the robot turns right.

## 4 Answer box

Players enter the number of wheel rotations that the robot should move to align exactly with the goal. Once the correct amount is entered, the robot leaps to the target.

	6.R.P.A.1	MP1	MP6
	6.R.P.A.2	MP2	MP7
	6.R.P.A.3	MP4	MP8
	7.R.P.A.3		

## Chapter 3: The Robot Garage



*The Robot Garage allows for robot customization.*

### 1 Reference ratio

Gives players an initial ratio of degrees to wheel rotations for the robot that they have assembled.

### 2 Parts List

In Chapter 3 players will be challenged to go and catch parts that are being dropped by the mother ship. They will need these parts to collect the jewels in Level 4.

### 3 The Robot Staging Area

This area is where the player can see the custom robot that they design. As they add parts, colors, battery level, etc. they will be displayed on their robot here.

### 4 The Robot Configurator

Initially there will only be a couple of parts that can be modified at the beginning of chapter 3. Once the student collects additional parts the parts will light up and they will be able to add them to their robot.

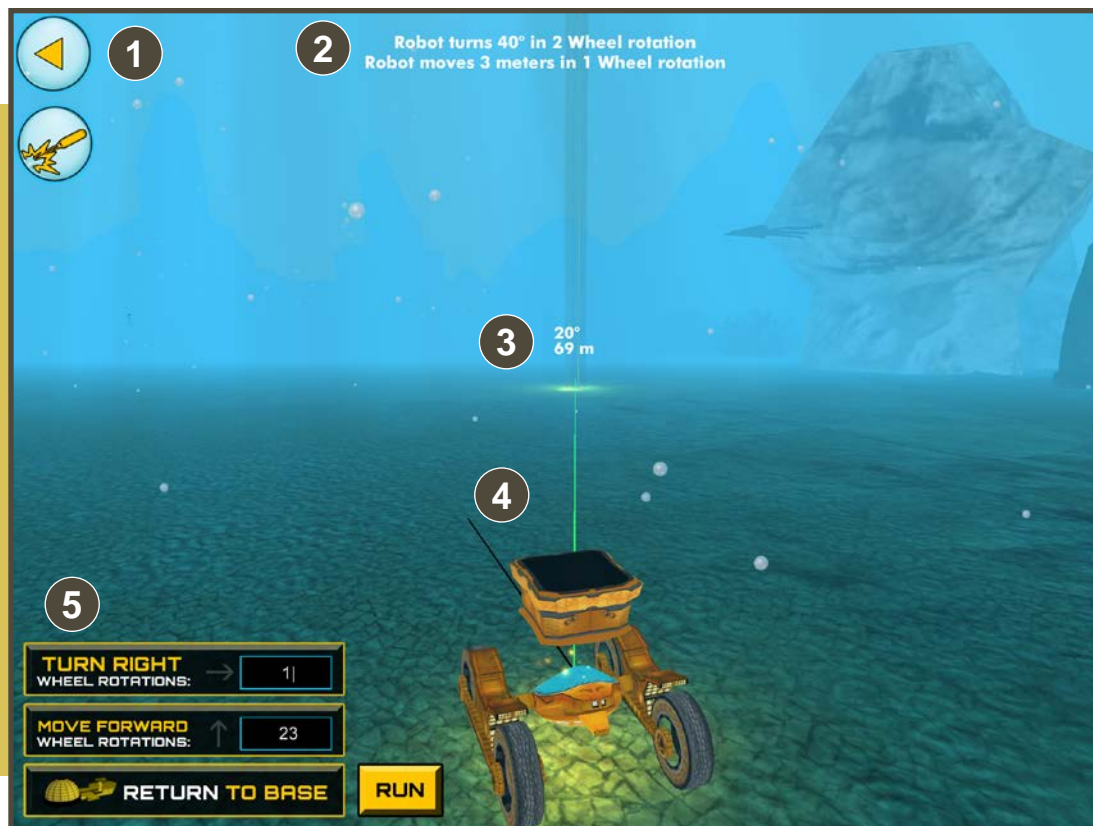
### 5 The Door to Level 3

This door takes players to outside Atlantis where they are required to catch parts from the Mother Ship.

### 6 The Door to Atlantis

This door remains locked until the player catches the key to the door.

# Chapter 3: Turning and Straight



*In Chapter 3, students combine the moving and turning skills they learned in Chapters 1 and 2. They catch parts that are dropped from the Mother Ship. They will need these parts to solve the Chapter 4 missions.*

## 1 Home / Robot Configurator

The top button takes the user back. The second button enables the student to add parts that they've caught to their robot.

## 2 Reference ratios

Players are given two reference ratios since they are now required to do two things: make their robot turn, and also move forward. This robot has a bigger wheel size, so both reference values have changed. For Explorer and Admiral levels, the reference ratios are no longer in the unit rate.

## 3 Goal/Upgrades


Each goal is the location where a new upgrade from Sebastian will be dropped. Each upgrade will equip the robot in different ways, especially for exploring Chapter 4, where the students reach Atlantis.

## 4 Robot

Players use a new robot with a catcher, increased wheel size and wheel separation distance. This affects the math for moving straight and for turning (see reference ratios)

## 5 Answer boxes

Students enter 2 values for each run. The direction of turning (left/right) is automatically handled and does not need to be manually set. The third "drop item at garage" is not a button; it only prepares students for future robot programming tasks where multiple steps are needed.

	6.R.P.A.1	MP1	MP6
	6.R.P.A.2	MP2	MP7
	6.R.P.A.3	MP4	MP8
	7.R.P.A.3		



# Chapter 4: Solving Atlantis



*In Chapter 4, students have reached Atlantis and need to reactivate the core generator by collecting five jewels in this level.*

## 1 The Measurement Tool

Players will be setting their own target locations in Chapter 4. Simply drag the measurement tool to the location that you want to travel to.

## 2 Distance Display

Once the measurement tool is moved it will display angles and distances relative to the robot.

## 3 Fuel Level

Green bars on the battery indicates the amount of fuel left in the robot. This battery is completely charged.

## 4 The Radiation Shield


In some of the rooms it will be advantages to use this tool.

## 5 Quick Travel

Once you have unlocked one of the four rooms in Atlantis, the quick travel button allows you to quickly move from on place to another.

## 6 The Answer Box

Works the same way in Atlantis as it did in Chapter 3.

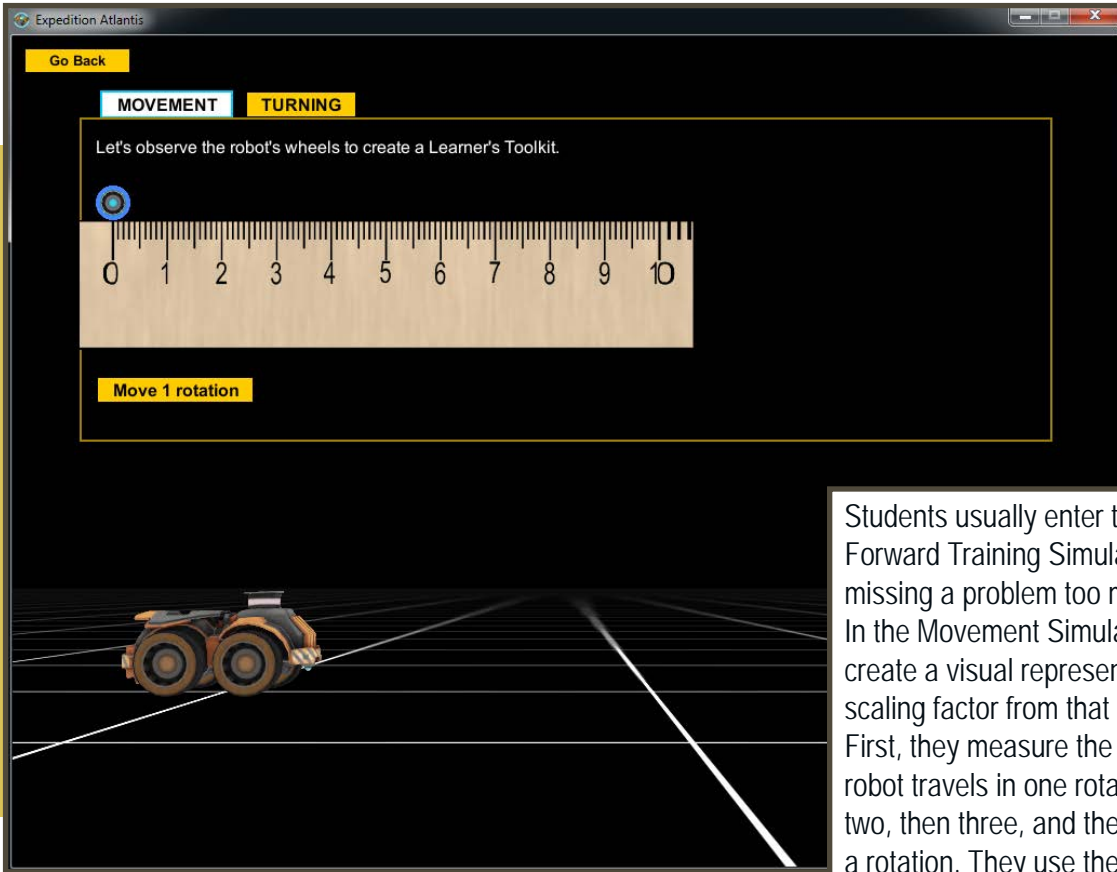
	6.R.P.A.1	MP1	MP6
	6.R.P.A.2	MP2	MP7
	6.R.P.A.3	MP4	MP8
	7.R.P.A.3		

## Quick Travel Tool

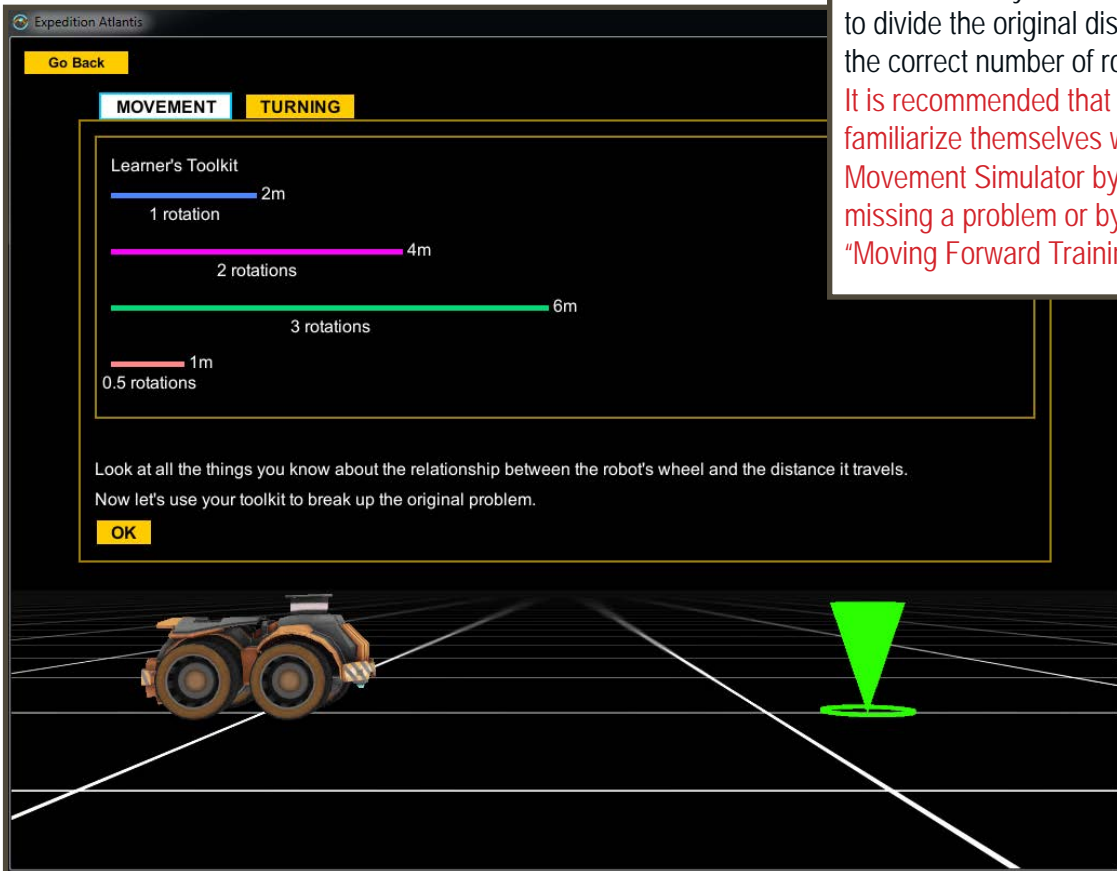


As rooms are unlocked in Level Four you will be able to quickly move from room to room by selecting **5**.

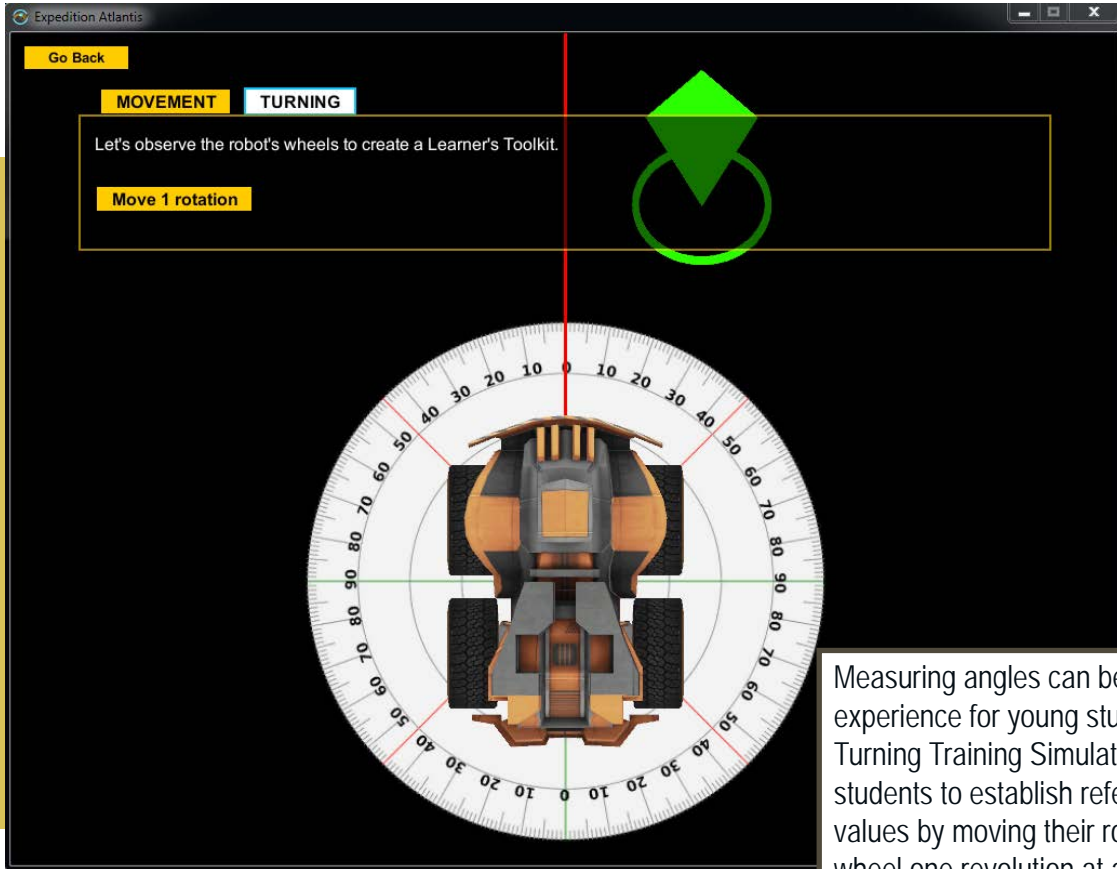
# Moving Forward Training



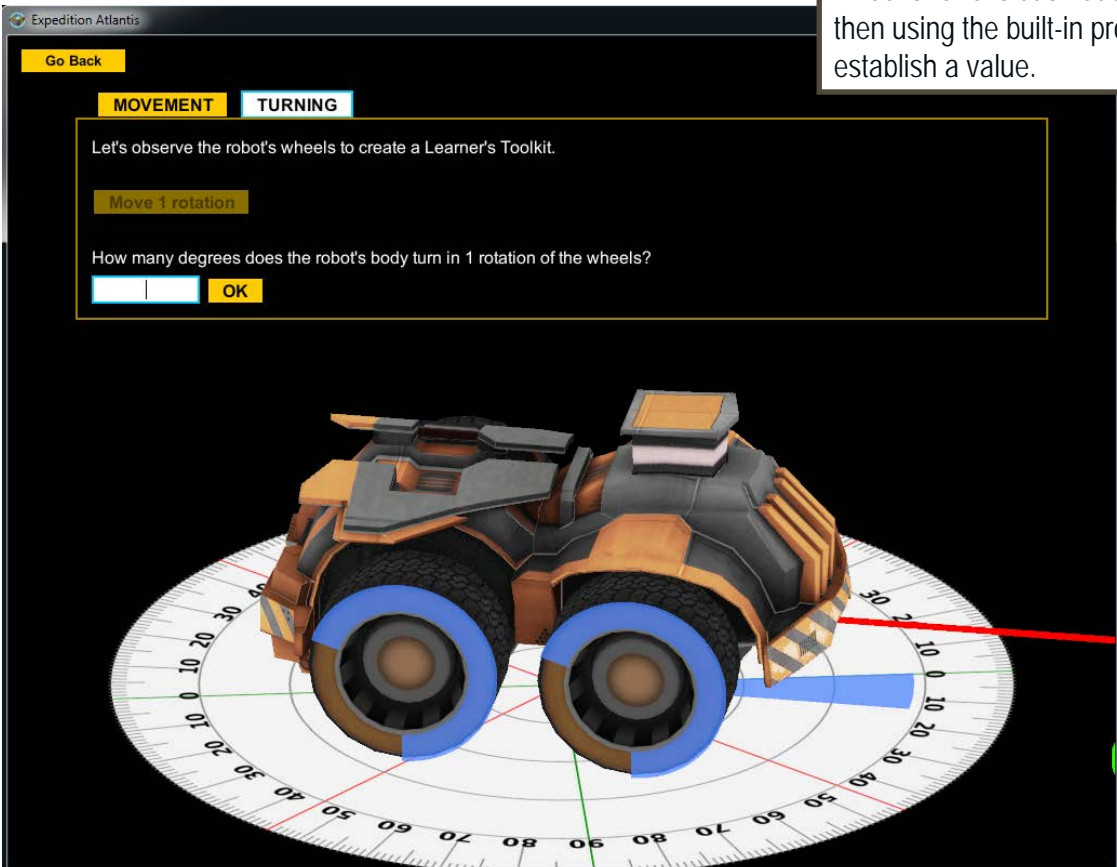
Students usually enter the Moving Forward Training Simulator after missing a problem too many times. In the Movement Simulator, students create a visual representation of the scaling factor from that problem. First, they measure the distance the robot travels in one rotation, then two, then three, and then one half a rotation. They use these values to divide the original distance into the correct number of rotations. *It is recommended that teachers familiarize themselves with the Movement Simulator by intentionally missing a problem or by selecting "Moving Forward Training".*



# Turning Training



Measuring angles can be a new experience for young students. The Turning Training Simulator helps students to establish reference values by moving their robots wheel one revolution at a time and then using the built-in protractor to establish a value.



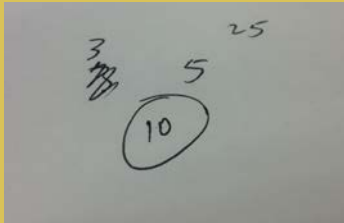
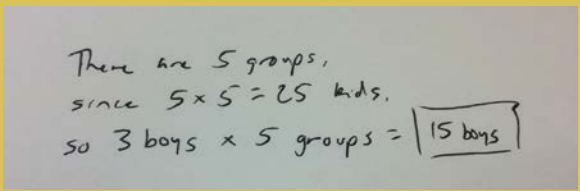
# Common Misconceptions: Magical Doubling!


*Students who magically double tend to have very little understanding of proportions.*

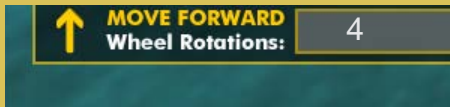
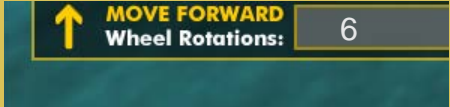
## How to detect

If the scale factor on a problem is more than 2 or 3, the student will feel overwhelmed and will just double or triple one of the reference values. The student often can't give a reason for the doubled answer, so we call it "magical" doubling.

**Ex.** Mrs. Smith has 25 students. She is able to divide them into groups of 5, with 3 boys in each group. How many boys are in Mrs. Smith's class?

<u>Magical doubling</u>	<u>No error (scaling approach)</u>
	

**Ex.**  Your robot moves 2m in 1 rotation. How many rotations do you need to move 12m?  
From chapter 1

<u>Magical doubling</u>	<u>No error</u>
	

## How to respond

- Use tone of voice to indicate a pattern:  
1 group has 3 boys, 2 groups have 6 boys, 3 groups have 9 boys... see how when you think about each group, there are another 3 boys? Now let's just see how many groups of 5 there are.
- Guide students to the Movement Simulator (accessible directly from the home screen; multiple wrong answers also trigger it). In the Movement Simulator, students can observe how far the robot moves in each rotation.
- If a student continues to have trouble, you can set a Custom level of difficulty, which ensures only simple whole number scaling factors.

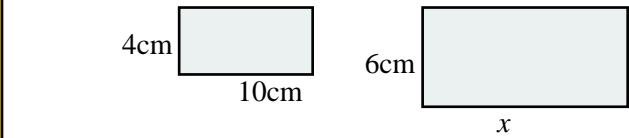
# Common Misconceptions: Additive Error

*Students who make this error tend to be in the process of acquiring basic proportional reasoning.*

## How to detect

Students will add or subtract to find the answer instead of multiplying or dividing. Sometimes they will explain that there are a certain number “more” or that they have to add to make it “equal.” The additive error occurs most frequently when the scale change factor is a fraction. So this is more common in extension questions, because in the game the unit rate is so close together (2m in 1 rotation).


**Ex.** A rectangle has been scaled up, as shown below. How long is  $x$ ?




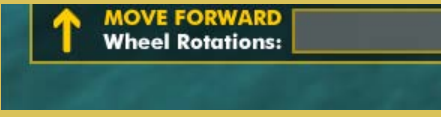
Additive error      No error (scaling approach)

The difference between 4 and 6 is 2. So to make them equal, you just go  $10 + 2 = 12$

The scale change factor is  $1\frac{1}{2}$ , since  $4 \times 1\frac{1}{2} = 6$   
 So  $10 \times 1\frac{1}{2} = 10 \times \frac{3}{2} = \frac{30}{2} = 15$

**Ex.**  Your robot moves 20 degrees in 1 rotation. How many rotations do you need to move 50 degrees?  
 From chapter 2

Additive error      No error

## How to respond

1. (Error in extension problem) Draw similarity to this problem and to problems in the game. “Why did you add here but multiply here?”
2. Extend the pattern to moving 2 rotations. “Does that follow addition?” (no)
3. Act it out: Stand side by side. Take 1 large step, have the student take 1 small step. Now take 2 more steps each. Is the distance between you the same as it was? (no)

Note: beware of extension problems that *aren't* proportional.  
 Ex. Joe is 13 years old. His younger brother is 9. When Joe is 26 years old, how old will his younger brother be?  
 Misapplying proportions, a student might say Joe's brother would be 18 years old. But there is no change scale factor - Joe and his brother are always the same number of years apart.

# Common Misconceptions: Incorrect Build-Up


Students who make this error tend to have a more advanced, intuitive understanding of proportions. Incorrect build-up is a limited case of the additive error.

## How to detect

Students will use addition, might be used to building up a proportional answer, e.g.. 3.25m in 1 rotation; 6.5m in 2; 9.75m in 3. But if the change scale factor is a fraction, they use addition for the uneven fractional part.

**Ex.** You can buy 5 bracelets for \$7. How much will it cost to buy 11 bracelets?

Incorrect build-up	No error (scaling approach)

**Ex.**  Your robot moves 3.25m in 1 rotation. How many rotations do you need to move 10m?  
From chapter 1

Incorrect build-up	No error

Note: mixed numbers not accepted. Answer must be entered as 28/9 or 3+1/9 or 3.11

## How to respond

1. Draw attention to fractional increases: .25m is what fraction of a rotation?
2. Simplify the reference values, leaving the scale change factor the same. For instance,
3. Build up their toolkits in the Movement Simulator

# Abstraction Bridge and Extension Activities

*These tools are designed as assessment tools and to generalize a student's mathematical understanding of the concept.*

## Chapter One Worksheet - (page 34)

The worksheet on page 34 is designed to help new learners think about the problem. The important part of the worksheet is where they use their own words to describe how to solve the problem.

## Word Problems/Abstraction Bridges - (pages 35 through 43)

Expedition Atlantis places mathematics into an underwater robotic context. Your goal as a teacher is to prepare students with a generalized understanding of mathematics. In order to do that it is critical for you to “see” how a student thinks. Make sure that your students “show and describe” how they got their answers.

## Extension Activities - (44 through 52)

The extension activity problems are designed to extend the learning into real-life proportional contexts such as speed, mixture, and density.

It is up to the discretion of the teacher to determine how the extension activities can be applied to their classes via:

1. A Large Group Instruction
2. Individual Instruction
3. Working as Partners
4. Combination of the above options

### 1. Large Group Instruction:

Teachers may give any of the extension activities to the entire classroom as a whole. Use the “Being Responsive to Student Thinking” script to guide the student through the lesson as a whole class activity. The benefits of doing the extension activities with the entire class as once is that the teacher is given the opportunity to model the mechanistic thinking that we would like the students to utilize as they work through the game. Additionally, the teacher can also try to elicit student responses that also model mechanistic reasoning for the rest of the class. The downside of doing the extension activities with a large group is it is very difficult for the teacher to ensure that every individual student is on task and every student is meeting the objectives of the class.

### 2. Individual Instruction

Teachers also have the option of giving each student a few of the extension activities to each of the individual students in class. This option gives the teacher



the opportunity to work with individual students as they complete the activities. Moreover, the teacher can collect student work at the end of class to check for individual student mastery. However, the teacher will have to wait until the next class period in order to correct any student misconceptions.

### **3. Partners**

Teachers can combine the two aforementioned methods, and have the students work as partners as they engage the extension activities. While working together, students can model for one another the mechanistic thinking involved in Expedition Atlantis. This method also asks students to communicate their math knowledge and processes, which is a desirable goal. Once again, though, teachers will have a difficult time making sure that all of their objectives are being met as the students work.

### **4. Combination of methods**

Fortunately, teachers can use a combination of the above activities while administering the extension activities.

- Model the mechanistic understanding for the students.
- Teachers can use the extension activities to demonstrate for the students how they should reason through a proportional reasoning exercise. Throughout this process, teachers can engage student feedback by asking for the appropriate steps as they reason through a problem.

### **Group Feedback**

Teachers can use questioning and discussion techniques with the whole class as they model how to answer a proportional reasoning problem. The benefits of doing this are that the teacher is able to clear up any misconceptions for the entire class, they are able to emphasize best problem solving practices, and the students and teacher can treat math as a communication.

### **Individual Feedback**

- After completing an exercise as a group, the students can then work on another extension activity individual, or with a partner. This then allows the teacher to acquire a more individualized form of feedback from the students. This feedback can then be used to help guide more formal assessments.

Teachers will have to make decisions as to how to best implement the Expedition Atlantis extension activities. There are many different variables that affect teachers and how they deliver their instruction. The extension activities are designed to be flexible enough to fit into every teacher's classroom. Teachers can then make decisions as to its implementation. This lesson script will serve as a useful tool as teachers make those implementation decisions.

# Expedition Atlantis Problem Solving

Answer the following questions as you attempt to solve the Expedition Atlantis problems.

1. How far are you trying to go in this problem?

This is the robot's target goal. (Include units) \_\_\_\_\_

2. What's the reference ratio that's already given to you? (Include units) \_\_\_\_\_

in every \_\_\_\_\_ rotations

3. Circle the numbers in questions 1 and 2 that are the same unit. What unit is that? \_\_\_\_\_

4. How many groups of that unit in the reference ratio go into the goal? \_\_\_\_\_

groups

5. Circle your answer for question 4 and the other part of your answer in question 2. This is the number of groups needed and the number of rotations per group. Multiply those together. This is how many rotations you need total to get to the goal. Write your answer in the blank. \_\_\_\_\_

rotations

Use your own words to describe how you solved the problem.

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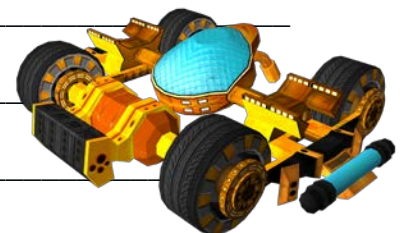
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# Robot Movements Question 1

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. Your robot moves 10 meters in 4 wheel rotations. How many wheel rotations does it take to move 30 meters?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ wheel rotations

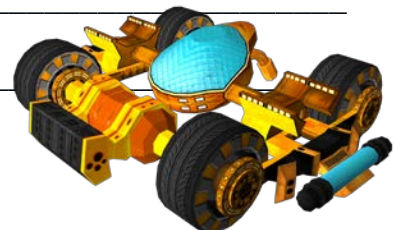
2. After today's lesson, what is one question you still have?

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# Robot Movements Question 2

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. Your robot moves 35 meters in 5 wheel rotations. How many wheel rotations does it take to move 56 meters?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ wheel rotations

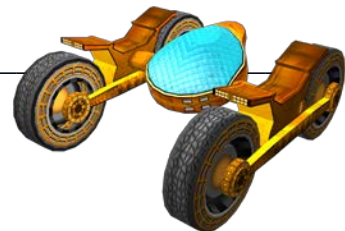
2. After today's lesson, what is one question you still have?

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# Robot Movements Question 3

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. Your robot moves 60 meters in 5 wheel rotations. The robot moves 9 wheel rotations. How many meters did it go?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ meters

2. After today's lesson, what is one question you still have?

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# A New Robot! Question 1

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You just purchased a new robot! The instructions say that for every 8 motor rotations programmed in the robot, it turns 5 degrees. How much will your robot turn if it uses 56 motor rotations?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ degrees

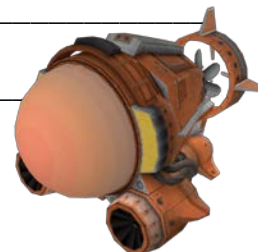
2. After today's lesson, what is one question you still have?

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# A New Robot! Question 2

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You just purchased a new robot! The instructions say that for every 14 motor rotations programmed in the robot, it turns 4 degrees. How much will your robot turn if it uses 49 motor rotations?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ degrees

2. After today's lesson, what is one question you still have?

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# A New Robot! Question 3

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You just purchased a new robot! The instructions say that for every 16 motor rotations programmed in the robot, it turns 4 degrees. (The motor is what makes the wheels turn, and a motor rotation is just a small part of the wheel turning.) Your robot turned 20 degrees. How many motor rotations did it go?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ degrees

2. After yesterday's lesson and your two days on Expedition Atlantis, what is one question you still have?

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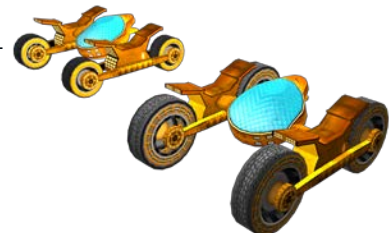
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# Going on a Trip Question 1

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You are traveling to visit a friend in another state. Your car has an 18 gallon gas tank and costs \$48.00 to fill up. You will use 54 gallons of gasoline in your travels. How much will you need to spend on gasoline?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \$ \_\_\_\_\_

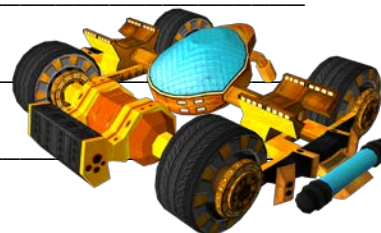
2. After today's lesson, what is one question you still have?

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# Going on a Trip Question 2

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You are traveling to visit a friend in another state. Your car has a 16 gallon gas tank and costs \$68.00 to fill up. You will use 52 gallons of gasoline in your travels. How much will you need to spend on gasoline?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \$\_\_\_\_\_

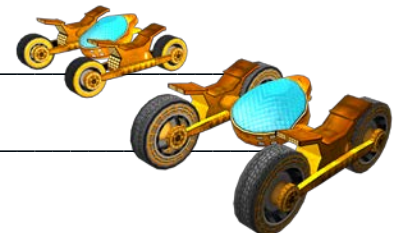
2. After today's lesson, what is one question you still have?

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# Going on a Trip Question 3

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. You are traveling to visit a friend in another state. Your car has an 18 gallon gas tank and costs \$63.00 to fill up. You spent \$192.50 in gasoline during your travels. How many gallons of gasoline did you purchase?

Please show all of your work and describe in words and pictures how you got your final answer.

Answer: \_\_\_\_\_ gallons

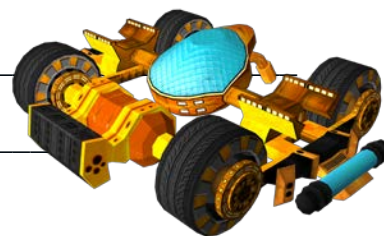
2. After today's lesson, what is one question you still have?

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## Tire Upgrade Problems (pages 44 - 46)

Once your robot reaches the base camp in Chapter 3, it will need to upgrade its wheel size to catch larger boxes of supplies from Sebastian. The size of the wheel (its circumference), is directly proportional to how fast the robot travels. Knowing this, we should be able to figure out how fast our robot is traveling with one of the larger wheel sizes. For example, a robot with a 2 meter wheel circumference travels at a speed of 15 km/hour. A robot with a 1 meter wheel circumference travels 7.5 km/hour.

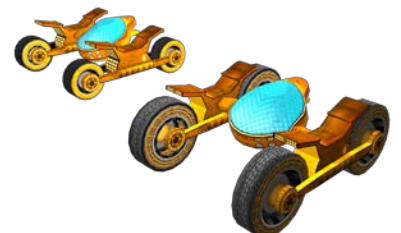
### Question #1

If the wheel on the robot is upgraded to a 5 meter wheel circumference, at what speed will the robot now travel?

### Question #2

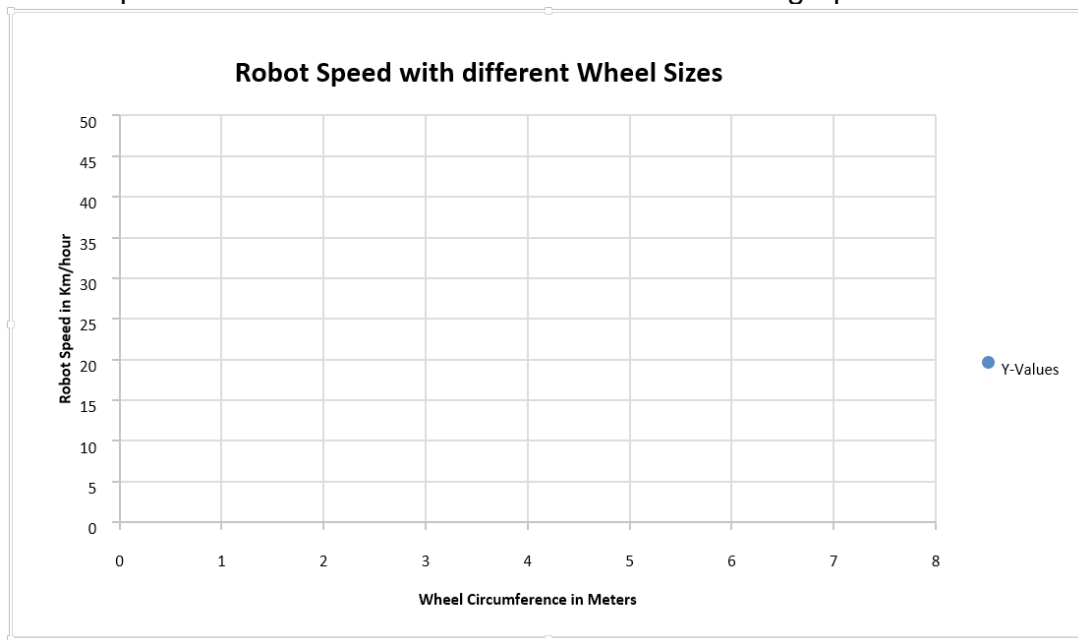
Apply your answer into the rate table below. Then, using your answers for the wheel circumferences of 1, 2 and 5, determine the speed for the remaining wheel circumferences.

Wheel circumference	Speed
1	7.5
2	15
3	
4	
5	
6	



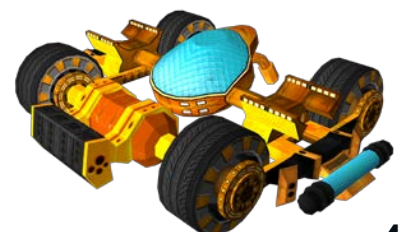
### Question #3

Plot the points from the rate table in Question #2 to the graph below:



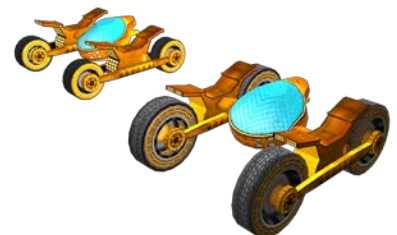
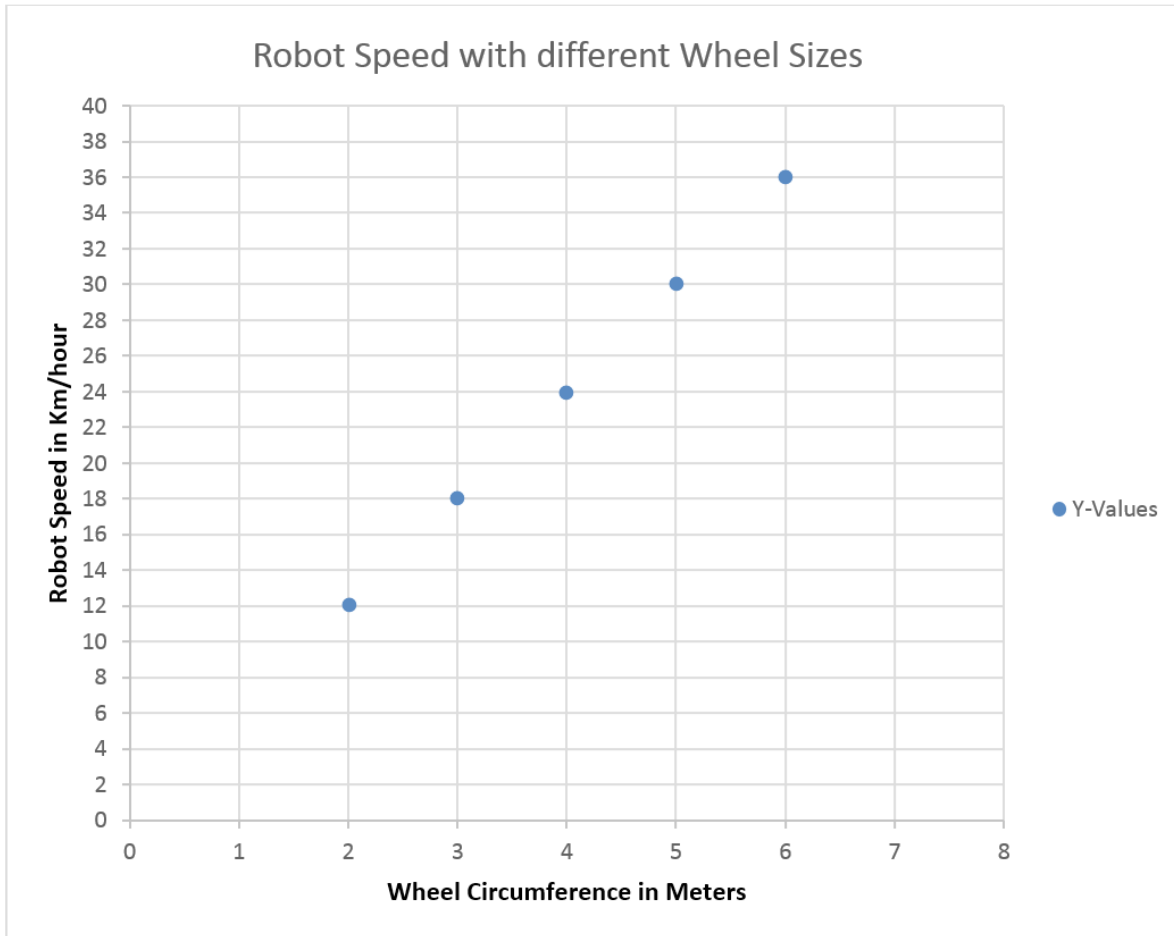
### Question #4

Based upon the information in the graph, if a robot had a wheel circumference of 4m, what would be its speed? Plot the point on the graph.



### Question #5

The speed of a different robot, outfitted with various wheel sizes, is displayed in the graph below. The relationship between the size of the robot's wheels and its motor speed is proportional. Using the graph, describe the following coordinate pair: (3, 18).

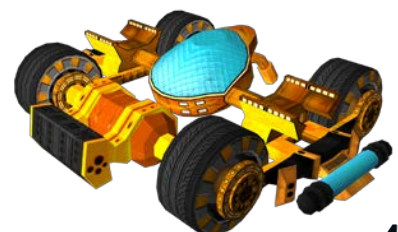


# Plow Upgrade Problem

Congratulations! You've finally reached Atlantis. You can now use some of the cool items that are in your robot garage to explore Atlantis and bring some of its artifacts back to Sebastian. One of those cool items is a plow attachment that can be placed at the front of your robot. With the plow attachment, the size of the plow's blade is directly proportional to the mass of the object that the plow can push. For example, a 5 meter plow can push objects up to a maximum mass of 1000 kilograms.

## Question #1

If your robot wanted to push items with a maximum mass of 3750 kilograms, what size blade would the robot need?



## Wheel Separation Size Problem

In chapter 3, our robot can get a larger chassis so that it can catch larger objects. When a robot gets a larger chassis, it makes the distance between the wheels larger. Luckily, the relationship between wheel separation size and the distance a robot turns is proportional. Therefore, we should still be able to make some precise turns. A robot with a distance between its wheels of 6 meters requires 4 rotations to make a 90 degree turn.

### Question #1

When the wheel separation size is increased to 18meters, how many wheel rotations would now be needed to make a 90 degree turn?



## Price Problems

The mission to Atlantis is taking longer than originally expected. It was impossible to predict that we would encounter an ocean storm, an ocean trench, and that we would have to resupply the base camp. As a result, Sebastian needs to purchase some new batteries to power the robots. Luckily, the relationship between the cost of the batteries and the number of batteries is proportional. Therefore, we can calculate our costs. Originally, Sebastian purchased 2 batteries for 26 dollars. It then purchased 9 more batteries at the same price as the original purchase.

### Question #1

How much did the mother ship spend for the 9 batteries?

### Question #2

Place your answer into the rate table below and complete the rest of the table.

Batteries	Price
1	
3	
	\$45
7	
9	
	\$143

### Question #3

Describe a method or a formula that would allow you to find out how much 30 or 300 batteries would be?

### Question #4

We actually just received a message from Central Command. We have been budgeted 500 dollars to purchase new batteries. The price is still the same as the original purchase of 2 batteries for 26 dollars. How many batteries can we purchase with the 500 dollars?

## Size Problems

Communication from Central Command has been breaking down and unfortunately they are not consistently able to orally tell us our movements. You will now you need to rely on a map to help determine how to get from your current location to Atlantis. The map scale tells us that for every 4 centimeters on the map that is 100 meters in distance. I measured 9 centimeters on the map.

### Question #1

How many meters will my robot travel?

### Question #2

We arrived at where we thought we were supposed to travel, but a storm blew us off course. We used a different map that is more detailed. This map scale tells us that for every  $\frac{3}{4}$  of a centimeter we travel 225 meters. During a brief connection, I thought central command told me I was 1125 meters away, but our communication was breaking down. To check their distance, how many centimeters will I measure on the map?

## Paint Mixing Problems

When we arrived at the robot garage we were informed that we could customize our robots with custom colors. A gallon of red, two gallons of white, and a gallon of blue paint will give us one particular color that we want (see graphic below).



### Question #1

If the paint job is going to take 24 gallons of paint total, how many gallons of each color will we need?

### Question #2

Illustrate and explain how you arrived at your answer.

### Question #3

We are able to customize our robot with a color mix of 3 gallons of yellow paint, and two gallons of green paint (see graphic below). If we used five gallons of green paint, how many gallons of yellow did we use?



# Density of Tire Spike Problem

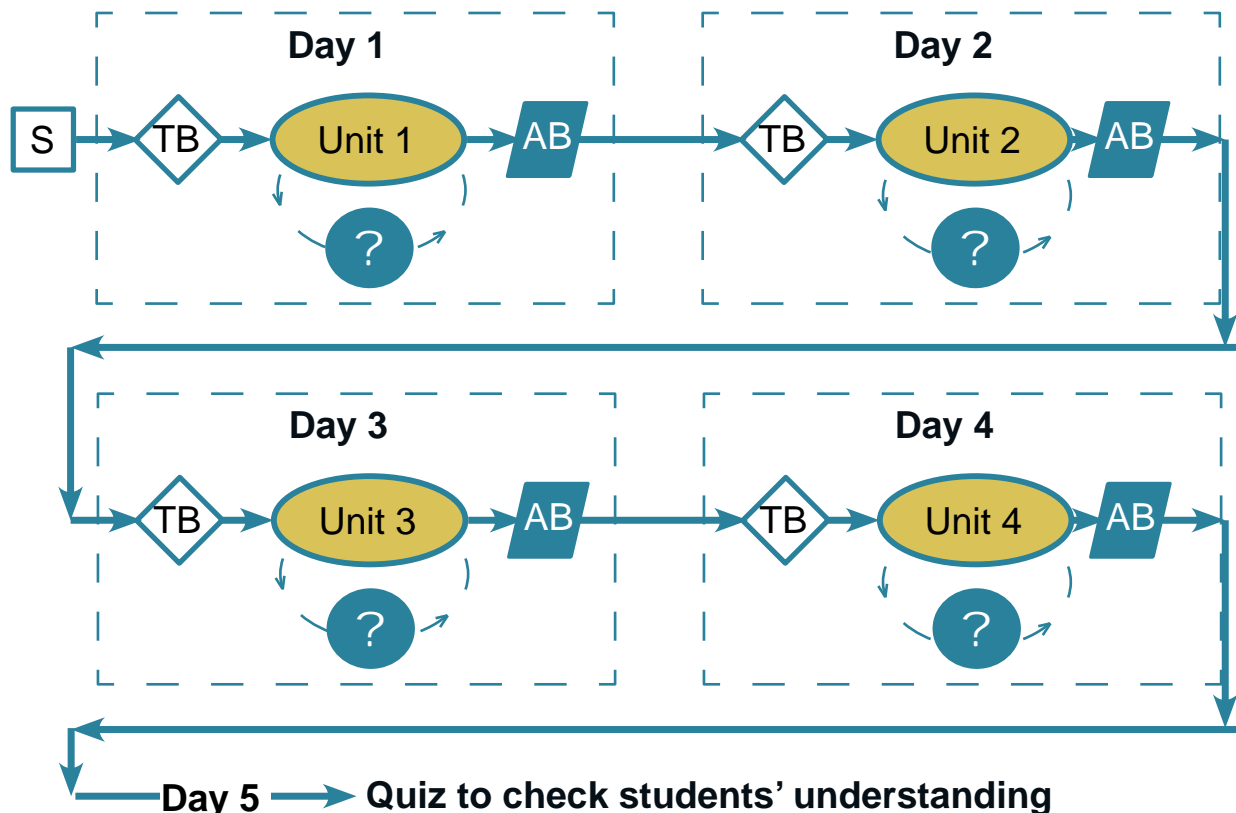
We have to travel across ice with our ice tires. Ice tires have little spikes that dig into the ice so the wheel doesn't slide. Look at your ice tires. We designed them after we looked at the Goodtire 3000.

## Question #1

If each tire moves 12m, which one will create more spike marks on the path? (pics of 2 wheels for visual comparison, our ice tire is 6m, the Goodtire is much smaller. Our ice tire has more spikes, but is less dense.)

According to the Common Core Math Standards, students begin learning about fractions in Grades 3 through 5, Angles in Grade 4, and Ratios and Proportional Relationships and Multi-digit Decimals are taught in the Grade 6; robotics is being introduced in some schools as early as 3rd grade and so not all students will be comfortable with decimals or what a proportionality is. The picture below shows a graphical representation of what a multi-day lesson might look like.

*Detailed lesson plans can be found starting on page 29 of this guide.*



**Symbol Legend**



*Setup - The classroom and computers are ready. See page ii checklist.*



*Teacher Briefing - an opportunity for teacher to set the stage for today's class*



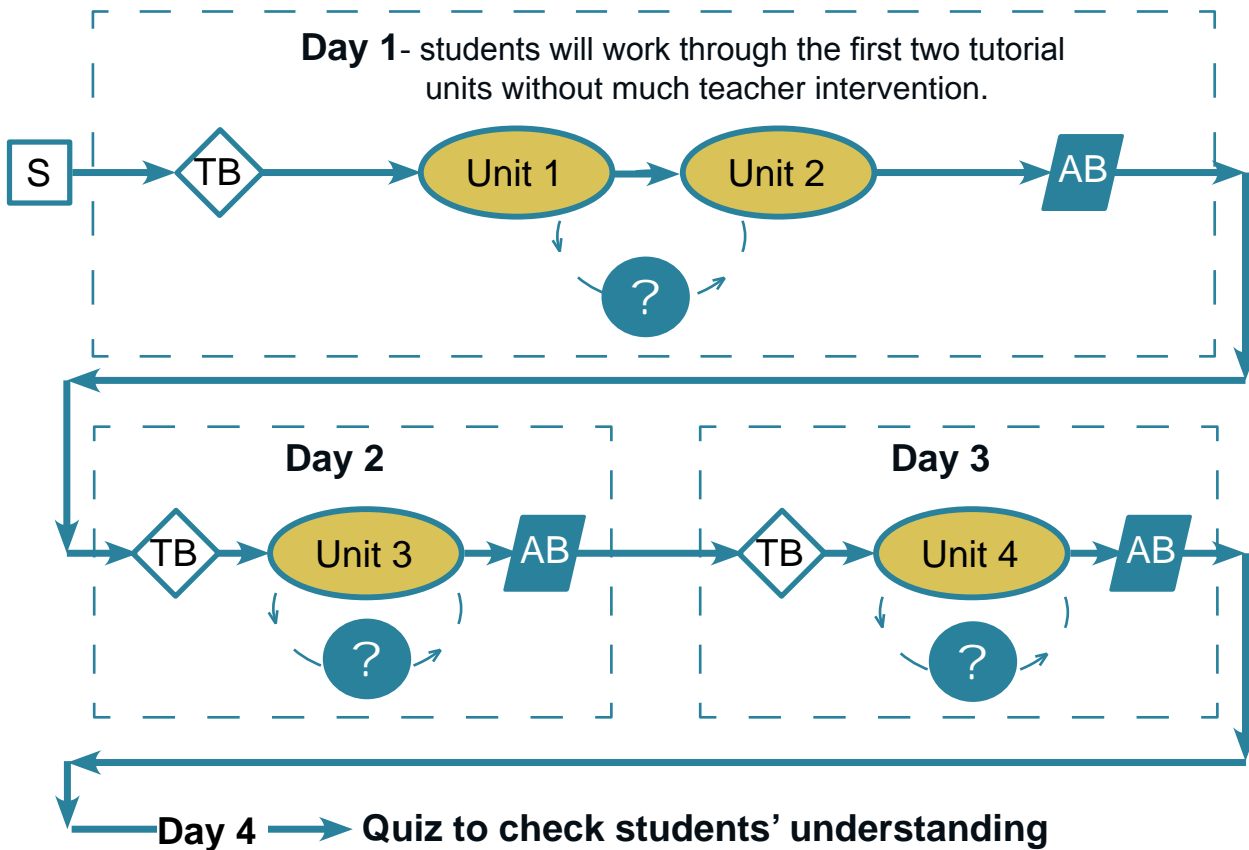
*Students play the game! The teacher observes students' progress and addresses individual and group questions as needed.*








*Abstraction Bridge Word Problems - A time for students to demonstrate and generalize their math understanding.*

Many students will have an intuitive understanding of proportionality but will benefit with contextualized practice. These students will have less problems with the introductory math shown in units 1 and 2 and will not need the same level of teacher intervention.

*Detailed lesson plans can be found starting on page 29 of this guide.*



**Symbol Legend**

-  Setup - The classroom and computers are ready. See page ii checklist.
-  Teacher Briefing - an opportunity for teacher to set the stage for today's class
-  Students play the game! The teacher observes students' progress and addresses individual and group questions as needed.
- 
-  Abstraction Bridge Word Problems - A time for students to demonstrate and generalize their math understanding.

# Individualized Educational Plans (IEP)

## In general, students with learning disabilities under perform in math

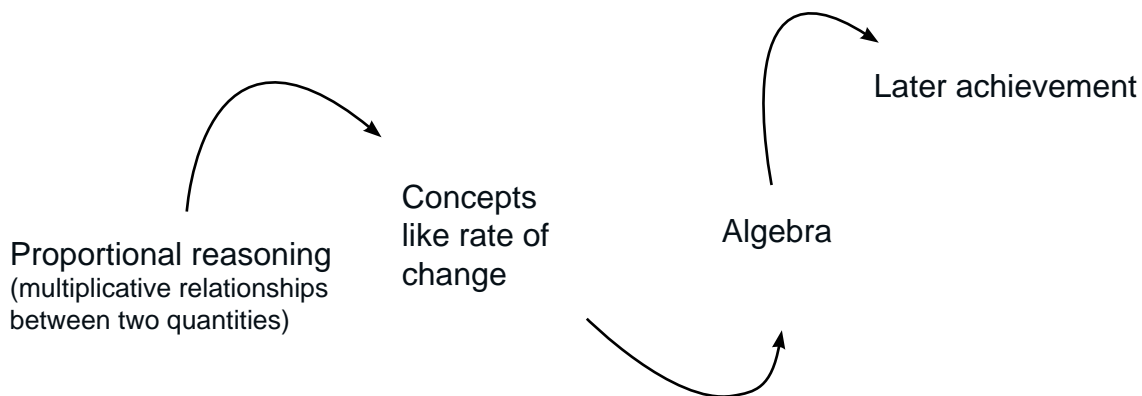
	4th grade	8th grade
Students with disability	19% at or above proficient in math	9%
Students with no disability	41%	35%

• National Center for Education Statistics, 2009

## Specifically, math IEP students need help in proportional reasoning

*“Students with a learning disability in math have a weak understanding of mathematical concepts that underlie success in Algebra 1, such as ratios and proportional reasoning.” (Hunt & Vasquez, 2013)*

*“Proportional reasoning evolves by the recognition of forms and structures of mental activity onto high-order levels ... these structures appear less expanded in children with [learning disabilities] than in their peers with [no learning disabilities], resulting in less coordinated inferences.” (Grobecker, 1999)*



### References

Hunt, J. H. & Vasquez, III. (2013). Effects of ratio strategies intervention on knowledge of ratio equivalence for students with learning disability. *Journal of Special Education XX(X)*, 1-11.

Grobecker, B. (1999). The evolution of proportional structures in children with and without learning differences. *Learning Disability Quarterly*, 22(2), 192-211.

# High Engagement

## Expedition Atlantis shows, it doesn't tell

### Premium Graphics

- ▶ Industry-standard 3D modeling software
- ▶ Video game engine in extensive use on iPads
- ▶ Design expertise from graduates of Carnegie Mellon's Entertainment Technology Center

### Enthralling Game Narrative

- ▶ The robot submarine *Sebastian* is on the precipice of the most amazing collection of all time – treasure in the ruins of Atlantis. But an ocean storm knocks *Sebastian* off course. Years of work finding Atlantis and establishing an underwater base camp nearby will be for naught unless you are able to guide a small robot explorer from the crash site to the base camp, and then into Atlantis to probe its treasures.

## Capitalizes on Student Interest

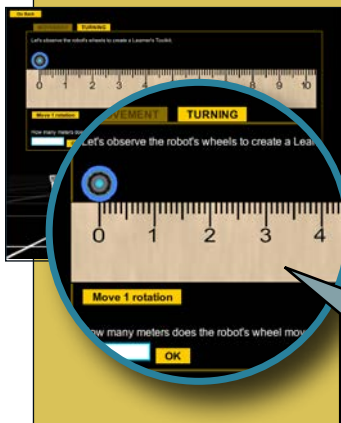
- ▶ Expedition Atlantis capitalizes on student interest in playing video games, and seamlessly embeds proportional reasoning concepts inside the game, so learning is natural.
- ▶ The interactive, 3D graphics give students powerful visual cues, allowing them to reason through the problems with instant visual feedback, bringing proportional reasoning to life.
- ▶ The theme, setting and natural progression of goals in the narrative allow students to work through the math of the game while they also work toward the goal of the game. As the math gets harder, the drama of the story increases to provide additional motivation.





## Research-Driven

### Mechanistic understanding

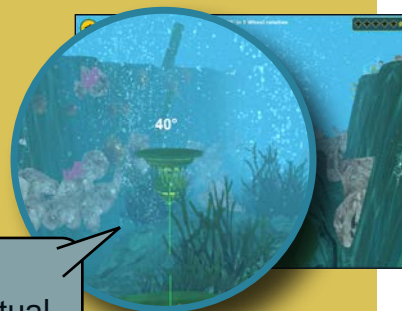


Students who develop a mechanistic understanding of proportions, where they use math to describe their intuitive ideas about how physical quantities relate, perform better than students who have a calculational understanding of proportions, where they use math as a set of fixed procedures (Silk and Schunn, 2011).

In Expedition Atlantis, we encourage a mechanistic understanding of proportions by using visuals of wheels turning, distance traveled, and angles turned to reinforce and test students' intuitive ideas.

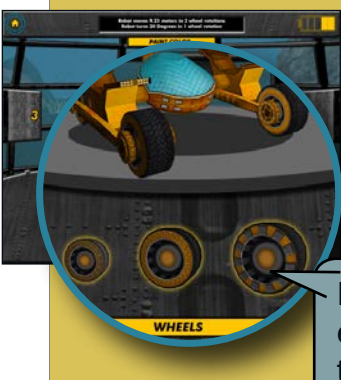
### Proportional thinking, not just methods

Cross-multiplication is highly efficient, but with something as conceptually important as proportional reasoning, we need to emphasize meaning as well as efficiency (Cramer and Post, 1993).



In Expedition Atlantis, students are not directed toward one method, but develop their own conceptual and procedural knowledge of proportions in the process of playing the game.

### Different contexts to build generalized understanding



In both instruction and assessment, teachers should vary the context of proportional reasoning problems, to include real-world contexts such as scaling, mixture, and density (Cramer and Post, 1993).

In Expedition Atlantis, extension activities incorporate examples of different real-world contexts based on the theme and narrative of the game in the supplemental resources section of this document.

### References

- Cramer, K. & Post, T. (1993, May). Connecting Research to Teaching Proportional Reasoning. *Mathematics Teacher*, 86(5), 404-407.
- Silk, E. M., & Schunn, C. D. (2011, June). Calculational versus mechanistic mathematics in propelling the development of physical knowledge. Paper presented at the 41st annual meeting of the Jean Piaget Society, Berkeley, CA, USA.

## Common Core



*This page focuses on 6th and 7th grade math standards and alignment with proportional reasoning. The game requires student to apply measurement, use fractions, divide decimals, and understand angles which are covered in the grades 3-5 Common Core Math Standards.*

### Standards for Mathematical Performance

**6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities

**6.RP.A.2** Understand the concept of a unit rate  $a/b$  associated with a ratio  $a:b$  with  $b \neq 0$ , and use rate language in the context of a ratio relationship

**6.R.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems

**7.RP.A.3** Use proportional relationships to solve multistep ratio and percent problems.

#### In Expedition Atlantis

Through the whole game, students use reference ratios to compute how far the robot should move and turn.

Students encounter unit rate questions in Chapters 1 and 2. For example, the robot turns 20 degrees per wheel rotation. How many rotations does it need to turn 60 degrees?

Extension questions (in this guide) ask students to compute rates in the contexts of mixture, density, speed, distance and turning.

Students are encouraged to solve the proportion problems using a multistep process (see “Solving the problems” in the Game Mechanics section).

### Standards for Mathematical Practice

These standards answer the question, “What skills should math educators at all levels seek to develop in their students?”

**MP1** Make sense of problems and persevere in solving them

**MP2** Reason abstractly and quantitatively

**MP4** Model with mathematics

**MP6** Attend to precision

**MP7** Look for and make use of structure

**MP8** Look for and express regularity in repeated reasoning

#### In Expedition Atlantis

Completing the game develops perseverance. The graphical interface helps students make sense of proportion problems.

Students must go beyond guess-and-check

Expedition Atlantis overall functions as a model for different proportional relationships.

Answers must be correct to the hundredths place.

Repetition game wide help students look for patterns

Game structure encourages finding general methods and shortcuts, especially in Chapter 4, which is timed.



