SPIRIT 2.0 Lesson:

Growing Circles

========== Lesson Header ==========

Lesson Title: Growing Circles (Finding $A = \pi r^2$ by experiment)
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Algebra Topic: Quadratics
Grade Level: 9 - 12
Cartoon Illustration Idea: Robots made with lots of circles, eating cans of spinach

Outline of Lesson

Content (what is taught):

- Modeling of quadratic functions
- Application of Experimental Design
- Analysis of and inference from data

Context (how it is taught):

- The robot is driven in circles on the floor marked with a small grid
- The radius and area of each circle will be measured (estimated)
- The data will be graphed, analyzed, and a model created to fit the data
- The robot will drive a circle not previously driven. The radius will be measured and the mathematical model/formula will be used to predict the area. It can be then checked by estimating the area using the floor grid

Activity Description:

In this lesson, the concept of quadratic data will be explored using the area of a circle. The formula for the area of a circle ($A = \pi r^2$) will be derived. To do this, a robot will be driven in a circle, of which the radius and area will be measured (estimated) using a small grid marked on the floor. The data collected will be graphed and modeled using a graphing utility. Finally, the robot will be driven in a circle different from any previous circle. The radius will be measured and the area calculated using the mathematical model/formula. This can be verified by estimating the area of the circle driven. The activity will conclude with a formal lab write-up explaining the results and what was learned.

Standards: (At least one standard each for Math, Science, and Technology - use standards provided)

Math
B1, B3, D1, E1, E2, E3
Science
A1, A2, E1
Technology
A4, C1, C2, C4, D3

Materials List:

Robot equipped to drive in circles
Floor of room marked with a small grid
Record Sheet
Graphing utility (calculator)
Measuring equipment

<u>ASKING Questions</u> (Growing Circles)

Summary: The teacher presents numerous different circles. Students will be asked if there are any patterns or relationships present in the circles. Students will be asked how potential relationships could be measured and data collected.

Outline:

- Present various circles to students on either the chalkboard or computer
- Ask students about possible relationships that could be present in the circles
- Instruct students to think about how they can design an experiment using a robot to collect data that will test their theories.

Activity:

Present many different circles. Ask students if there are any patterns or relationships present in the circles. Guide the students to radius and area ($A = \pi r^2$), which will be an example of quadratic data. Students will decide on an experiment using a robot driving in circles to test their hypothesis.

Questions	Answers
What relationships are present in these circles?	There are many but we are concerned with something to do with the area and how it seems to grow bigger as the radius increases.
What will be necessary to test for the suspected relationships?	An experiment where many data sets are collected.
How can a robot be used to test this theory?	Drive the robot in circles and measure the diameter and circumference?
How can the area be found in the experiment?	Mark the circle in the floor with a small grid on it and then estimate the area by counting the squares. The smaller the grid the better the estimate.

Image Idea: A robot on a floor grid

<u>EXPLORING Concepts</u> (Growing Circles)

Summary: Students will modify a robot causing it to drive in a circle. The radius of the circle driven will be measured and the area estimated by using the small grid on the floor. The process will be repeated to create a data set.

Outline:

- Students will modify a robot so that it drives in circles
- The robot will be driven in circles
- The radius will be measured and the area estimated using the grid on the floor,
- Record all data on a data chart
- Repeat this process until an adequate data set (at least 5 different circles) is created

Activity:

Students will create different sized circles using the robot. The robot can be modified so that one wheel goes faster than the other, by placing resistors on one motor and not the other thus slowing only one motor. It also can be done just by driving in circles (this is possible with practice). It depends on the depth of the experiment you wish to create. If you use resistors, you can discuss parallel and series physics concepts as well. The radius will need to be measured and area will need to be estimated. The robot can have a marker or chalk attached to it to mark the circle driven. Different colors can be used for the different sizes of circles. Another possibility is to place a string along the path of the robot marking the circle it "drove" to help with this process. The radius can then be measured and the area estimated by using the string. (Students can be given techniques or they can come up with them on their own.) The process needs to be repeated until there is a minimum of five data points.

Videoclip Idea: Robot with a marker/chalk attached to it or someone placing a string on its path with a grid on the floor while the robot is driven in a circle.

<u>Instructing Concepts</u> (Growing Circles)

<u>Filled in by math content writing team</u>

<u>ORGANIZING Learning</u> (Growing Circles)

Summary: Students organize the data collected in the experiment in a chart. Graph the data and create a model using a graphing utility (or calculator). The data should appear parabolic.

Outline:

- Organize the data collected in a chart
- Graph the data
- Analyze data for a trend and students will decide if that trend fits their hypothesis about the problem that was presented
- Create a mathematical model using a graphing utility or calculator. It should be very close to $A = \pi r^2$.

Activity:

The data previously collected will need to be organized in a chart and graphed by the students. (Students can decide how to do this or can be guided.) Make sure students understand how to use the charts and what they are trying to determine when solving these problems. Upon completion of the experiment look over their charts and quickly assess how students are doing. After the data is graphed, students need to look for patterns that can be modeled. Push students to look at the data and analyze constantly about the results. Below are questions that the teacher should ask the students to help them process the experience.

<u>Question 1</u>: Did the collection go as desired?
<u>Question 2</u>: Were there any problems that might have caused data to be flawed?
<u>Question 3</u>: Is there a relationship in the data being sure to consider all possibilities?
<u>Question 4</u>: Are there any other things that possibly affected the results of the experiment?

Calculate a model for the data using a graphing utility

Circle	Radius	Estimated Area	Notes
1			
2			
3			
4			
5			

UNDERSTANDING Learning (Growing Circles)

Summary: Students write a formal lab write-up with the experimental procedure, the data, and the model calculated. Discuss possible errors that might have occurred during the process. (It might be a good time to talk about measurement error and allowable error for experiments.) They will then drive the robot in a circle of size not previously completed. The radius will be measured and the area calculated using the model created. The result can be tested by estimating the area of the circle driven in the same manner as the data collection.

Outline:

- Formative assessment of quadratic functions
- Summative assessment of quadratic functions

Activity:

Formative Assessment

As students are engaged in the lesson ask yourself or your students these or similar questions:

1) Can students explain the concept of a quadratic function including the shape?
2) Are students able to apply the concept of quadratic functions to other real life situations?

Summative Assessment

Students will write a formal lab write-up including the experimental procedure, the data, the model calculated, and things that might have effected the results.

Students will complete a performance assessment by "driving" the robot in a circle of size not previously completed. The radius will be measured and the area calculated using the model created. The result can be tested by estimating the area of the circle driven in the same manner as previously done.

Students will answer one of the following writing prompts:

1) Explain why this experiment was modeled using a quadratic function using the concepts and mathematical terms learned in this lesson.
2) State another real life example that could be modeled with a quadratic function and why.

Students will complete the following quiz questions as follows:

1. The classroom robot travels in a circle with a radius of 6.5 in. Use your model to determine the area of the circle created.
2. A circular NASCAR racetrack is 2.3 miles in diameter. Use your understanding to determine the area of the circle created by Jeff Gordon as he drives a lap.

Click for a possible grading rubric
(http://www.rcampus.com/rubricshowc.cfm?code=M2W634&sp=yes)

See Below: