SPIRIT 2.0 Lesson:

Consistent Circles

==========**Lesson Header** ==========

Lesson Title: Consistent Circles
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Algebra Topic: Direct variation
Grade Level: 8 - 12
Cartoon Illustration Idea:

Outline of Lesson

Content (what is taught):

- Introduction of direct variation
- Application of experimental design
- Analysis and inference from data

Context (how it is taught):

- The robot is driven in a circle with the diameter and circumference being measured. This process is repeated to create a data set
- The data will be graphed, analyzed, and a model created to fit the data
- The robot will drive a circle not previously driven. The diameter will be measured and the model will be used to predict the circumference.

Activity Description:
In this lesson the concept of direct variation will be explored using a robot driven in many different sized circles. The diameter and circumference of each circle will be measured and recorded. The data collected will be graphed and modeled using a graphing utility. The students should discover the constant "pi" in this model. Finally, the robot will be driven in a circle different from any previous circle. The diameter will be measured and the circumference calculated using the model. This can be verified by measuring the circumference 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, F5
Technology
A4, C1, C2, C4, D3
Materials List:

Robot equipped to drive in circles by using resistance or other means
Measuring equipment
Graphing utility (calculator or computer)
String to place along the circumference of the circle as it is driven.

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

Summary: The concept of variation will be explored by looking at circles and discussing the relationships between diameter and circumference. Students will design an experiment to confirm this relationship.

Outline:

- Present various circles to students, either on chalkboard or computer
- Ask about possible relationships that could be present between the circles.
- Determine how an experiment can be designed using a robot to collect data to test their theories.

Activity:

The teacher will present many different circles and ask students if there are any patterns or relationships present in the circles. There are many relationships but the students need to be steered to circumference and diameter that will be an example of direct variation. They will need to 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 (radius to diameter, radius to area, radius or diameter to circumference, circumference to area) but we are concerned with something to do with the diameter and circumference.
• 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.

Image Idea: Various circles with different diameters

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

Summary: Students will modify a robot so that one wheel goes faster than the other causing it to drive in a circle. The diameter and circumference will be measured and recorded for each circle created. 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 and the diameter and circumference will be measured and recorded
- Repeat this process at least 5 times until an adequate data set is created

Activity:

Students will create different sized circles using the robot. This may be done 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). If you use a resistor, you can discuss parallel and series physics concepts as well. The diameter and circumference will need to be measured for each circle created. Place a string along the path of the robot marking the circle it created. The diameter can then be measured and the circumference can be found by measuring the length of the string. Students can come up with this technique on their own or you can determine the process.) The process needs to be repeated until there are a minimum of 5 data points.

Videoclip Idea: Robot on the floor driving in a circle with someone placing a string on its path

Instructing Concepts (Consistent Circles)

Filled in by math content writing team

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

Summary: Organize the data collected in the experiment in a chart. The data will be graphed and a model created by using a graphing utility (or calculator). The constant of "pi" should be "discovered". All models that students create should be $C = \pi d$. They might not be exact because of the possibility of measurement error. Remember the concept of direct variation is where both variables either increase or decrease in a constant manner.

Outline:

- Organize the data collected previously in a chart
- Graph the data
- Analyze the data for a trend that is present
- Create a mathematical model using a graphing utility or calculator.

Activity:

Students collect data and organize it in a chart. The data is then graphed. Students can decide how to do this or can be guided. Ensure that students understand how to use the charts and know exactly what they are trying to discover/prove in the lab. Upon completion of the experiment look over their charts and assess how students are doing. After the data is graphed, students need to look for patterns that can be modeled. Push students to study at the data and analyze the results.

Below are questions that the teacher should ask students to make them think about the experiment and how well the collection of data went. They should help students think critically about the process.

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

Calculate a model for the data using a graphing utility.

Circle	Diameter	Circumference
1		
2		
3		
4		
5		

UNDERSTANDING Learning (Consistent Circles)

Summary: Students compose a formal lab write-up with the experimental procedure, the data collected, and the model calculated. Discuss the 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 diameter will be measured and the circumference calculated using the model created. The result can be tested by actually measuring the circumference that was driven.

Outline:

- Formative assessment of direct variation
- Summative assessment of direct variation

Activity:

Formative Assessment

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

1) Can students explain the concept of direct variation?
2) Are students able to apply the concept of direct variation 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. They will then "drive" the robot in a circle of size not previously completed. The diameter will be measured and the circumference calculated using the model created. The result can be tested by actually measuring the circumference that was driven.

Students will answer the following writing prompt:

1. Explain how direct variation worked on the variables in this experiment using the concepts and mathematical terms learned in this lesson and then state another real life example of direct variation and why.

Students could answer these quiz questions:

1. A race car is traveling on a circular track that has a diameter of 2.5 miles. Using this data, and what you have learned today, find the circumference of the race track.
2. Given that a circle has a circumference of 30 feet calculate the diameter of the circle.