Subject Area(s) Physical Science

Activity Title Battle Bots

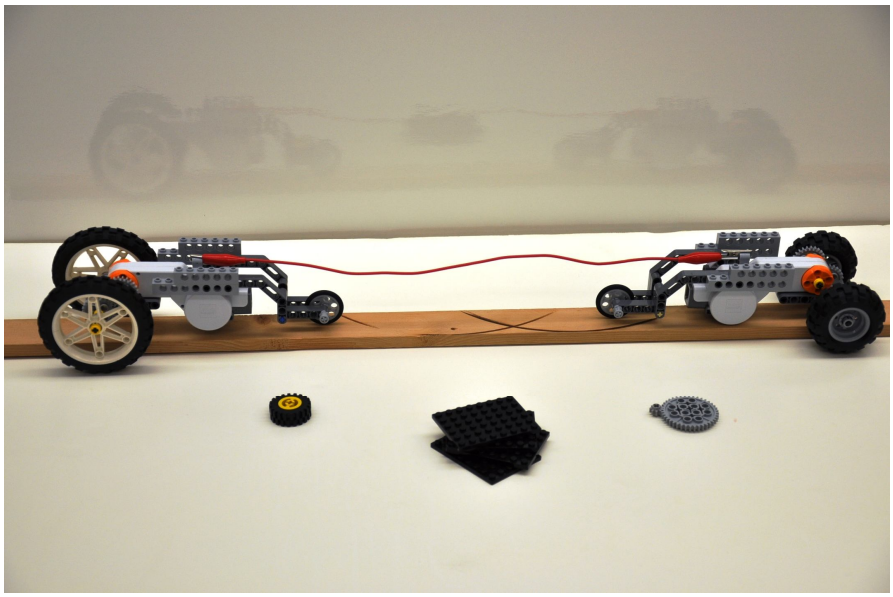

Image 1

Caption: Battle Bots setup with accessories

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Grade Level 9 (9-12)

Activity Dependency

Time Required 45 minutes

Group Size Relative

Expendable Cost per Group US $ 0

Summary This lesson introduces students to torque, power, friction, and gear ratio. Two students/teams modify a robotic Lego vehicle by changing its gear ratio, wheel, size, weight, and engine power. Students are given a certain amount of points to spend on modifications. An upgrade in gear ratio or wheel size will result in a larger amount of points being deducted from their total. These robots are then put on a track opposite each other with a rope attaching one to the other. The robot with the right adjustments will pull the other robot across a line signifying it has won.

Engineering Connection Mechanical Engineers encounter torque in many systems, such as a car. Gear ratios also play large roles in the operation of cars, which use automatic and manual transmissions in order to switch to a necessary torque output for the terrain a car is driving on. Knowledge of these concepts enables systems to run more efficiently and safely.

Engineering Category Provides engineering analysis or partial design

Keywords Friction, Gear Ratio, Power, Robot, Torque

Educational Standards

State science:
• Potential and kinetic energy PS 4.1e
• Mechanical energy PS 4.1d
• Machines can affect the magnitude or direction of a force required to do work, or the distance over which that force is applied. PS 5.2f
• Simple machines include the lever, the pulley, the wheel and axle, and the inclined plane. PS 5.2g

State math:
6.PS.10 Work in collaboration with others to solve problems
6.PS.16 Discuss with peers to understand a problem situation
6.CN.4 Understand multiple representations and how they are related

Pre-Requisite Knowledge

Learning Objectives After this activity, students should be able to:

- Identify gear ratios and the significance of each to the solution of a problem
- Understand that the solution to an engineering problem may be reached by many ways
- Learn to work with others to solve a problem
- Understand the concepts of torque and its application to the activity

Materials List

Each group needs:

- One Lego robot with interchangeable parts including gears, extra legos for weights, and wheels

To share with the entire class:

- A track to keep robots in alignment
- String to tether the two robots together

Introduction / Motivation Anyone who has ever played tug of war knows that the winner is usually the stronger or heavier of the two and if you've watched drag racing, you know that the fastest car wins the race. So if we combined the two activities, what would a winning car be like? (Teacher lists off characteristics of both winners at each activity) That's exactly what this activity is about. We will build our own tractor pullers out of Legos with the object of pulling your opponent over the line. What makes these cars so powerful or fast? Have you heard of concepts like torque, power, friction, or gear ratio? (Teacher shows diagrams of each concept) You will have a specific amount of points in which you can spend modifying your cars. Parameters can include, power,

wheel size, gear ratio, and weight. We will put the cars on a track and whichever team pulls the other's tractor over a line wins the game.

Procedure

Background: In order that the students understand what makes a successful machine, they will need to develop an understanding of torque, power, gear ratio, and friction. First the teacher should explain torque in a simple manner, perhaps using a seesaw analogy (force x lever arm). Then power of the engine, which can be explained as work/time or in a simplistic form for the sake of the lesson, as a number value for the Lego Mindstorms interface. Thirdly, the teacher shall explain gear ratio building upon the concept of torque. A simple pre-activity could be measuring diameters of wheels and making gear ratios. The teacher can then explain the characteristics of each. For example a small gear ratio, enables large torque, but translates to low speed, and vice versa. Lastly, the teacher can demonstrate the problems in design when a car does not have enough friction to support the turning of its wheels, like cars on ice or drag racers burning their wheels.

Before the Activity

- Show students how to interchange parts to their Lego vehicles so that they may make adjustments
- Group students to liking

With the Students

1. Allocate a certain number of points to each group
2. Allocate a certain number of points to modifications (i.e. more weight to racer equals five points)
3. Have students build racers and test design flaws, but no practice runs pulling objects
4. Fasten string to each vehicle and commence pulling until one vehicle is pulled over a line. (can use midline as pull line or a shorter distance if necessary)
5. If more than two groups, do round robins or tournament format to declare winner.
6. Discuss the design of each racer and the characteristics

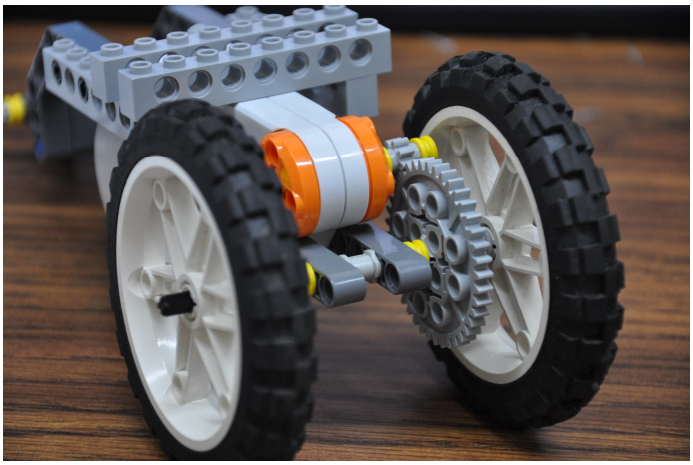

Figure 1

Caption: Gear ratio and wheel size of robot 1

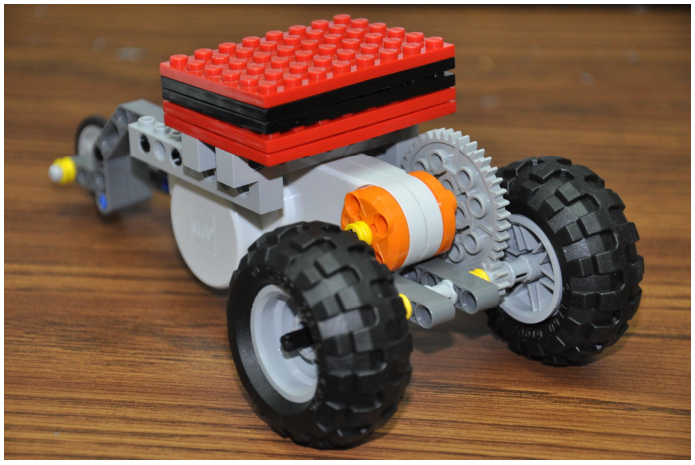

Figure 2

Caption: Gear ratio, weight, and wheel size of robot 2

Assessment

Pre-Activity Assessment

Descriptive Title: Conceptual Identification

Before the activity, start by drawing two lines with different length on a board. Ask if a force was applied, which one has more torque? Now translate that to simple gear ratios. See if the students understand that different gear ratios can provide different torques, which can translate to different speeds. For friction, have students try to pull a piece of paper with a stapler on it across the desk. Now try it with a pencil. Which one is harder to pull? Why? Now translate that concept to wheels and how they need to have enough weight to have friction make them move.

Activity Embedded Assessment

Descriptive Title: Does it do what I want it to do?

As the students are designing and making their vehicles, tell them to run the vehicle for a while and see how fast it may go compared to the others. Is this a race? Can I pull more if I am traveling slower, or vice versa? If they students can answer these questions logically, then they will have a good idea of how to build a vehicle that performs well.

Post-Activity Assessment

Descriptive Title: Discussion

Discuss the process of design for each group. What gear ratio did they use? How big were the wheels? Did they have enough weight? See what the characteristics of each tractor. Which is the fastest or slowest? Why? Which one finished ahead of the other? By discussing their designs students should recognize some flaws or alternate solutions to their problems.

Activity Scaling

- For lower grades, decrease the amount of modifications the teams can make to their robots. If topics appear too advanced, focus primarily on gear ratio and the advantages that the robots can gain from different gear ratios.

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