Electronic supplemental material #1

This electronic supplemental material provides information about the two inquiry units used for the intervention groups of the parent article entitled "The Effect of Guidance during Inquiry Instruction on School Science Achievement Motivations".

Unit 1: Inclined planes

Research question

Students are introduced to inclines planes and asked to design a ramp that could be used by people in wheelchairs to access a building with the least possible effort. The research question for this investigation is:

What factors affect the amount of force that must be used to move an object on an inclined plane?

Procedure

Students design inclined planes and they measure, using a dynamometer, the amount of force needed to pull an object up the ramp (Figure 1). A block (grey square) is attached to a small bag (blue rectangle) hanging at the top of the inclined plane (white triangle). Students gradually introduce 1 cent coins into the bag (Step 1) until the block moves from point A to B, recording the number of coins used. Afterward, students use a dynamometer (Step 2) to determine the force applied by the bag containing the coins, recording their results.

Step 1 Step 2

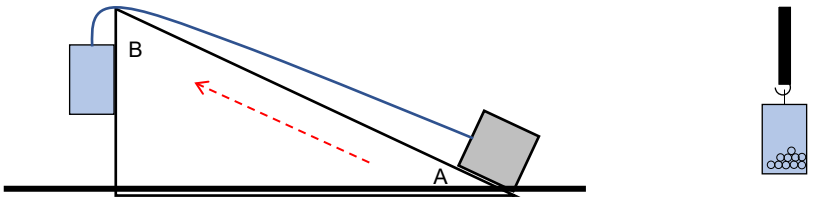

Figure 1. Basic setup for the experimental procedure

Three different experiments are conducted:

Experiment 1: Inclination angles

Dependent variables: Amount of force (number of coins and Newton value determined using the dynamometer)

Independent variables: Angle of inclination of the inclined plane (Increasing by 10º until reaching 50º of inclination).

Control variable: Length of the inclined plane; surface of the inclined plane

Experiment 2: Length of the inclined plane

Dependent variables: Amount of force (number of coins and Newton value determined using the dynamometer)

Independent variables: Length of the inclined plane (3 different lengths)

Control variable: Angle of inclination of the inclined plane; surface of the inclined plane.

Experiment 3: Surface

Dependent variables: Amount of force (number of coins and Newton value determined using the dynamometer)

Independent variables: Surface of the inclined plane (different levels of roughness)

Control variable: Angle of inclination of the inclined plane; length of the inclined plane.

Results

Students conclude that the angle of inclination, length, and surface of the inclined place determines the force needed to move the object. The lower the angle the inclination, a relative length, and the smoother the surface, the easier it will be to move the object.

Unit 2: Designing parachutes

Research question

Students are introduced to parachutes and asked to design a parachute that descends as slowly as possible. The research question for this investigation is:

What factors influence the descending speed of a parachute?

Procedure

Students design different parachutes following instruction based on the "Design a Parachute" activity designed by *TechEngineering*, which can be found here:
https://www.teachengineering.org/activities/view/design_a_parachute

Students launch the parachutes from an average height and record the descent time for each parachute. Then, they compare the descent time according to each variable and determine how the size, shape, length of the rope, and material should be used to build a parachute that descends as slowly as possible.

Four different experiments are conducted:

Experiment 1: Size of the parachute

Dependent variables: Descent time

Independent variables: Size of the parachute (three different sizes)

Control variable: Shape; rope length; material.

Experiment 2: Shape of the parachute

Dependent variables: Descent time

Independent variables: Shape of the parachute (triangle, rectangle, square, and circle)

Control variable: Size; rope length; material.

Experiment 3: Parachute rope length

Dependent variables: Descent time

Independent variables: Three different lengths

Control variable: Size; shape; material.

Experiment 4: Material used to build the parachute

Dependent variables: Descent time

Independent variables: Three different materials ((coffee filter, paper, transparent, plastic bag)

Control variable: Size; shape; rope length.

Results

Students are introduced to the air resistance concept and that the parachute with the largest surface area, built using the least porous material, with a longer length of strings, and with a round shape, is the parachute that retains the most air within and therefore will be the one that descends the slowest.